SCIENCE FOR MODERN LIVING

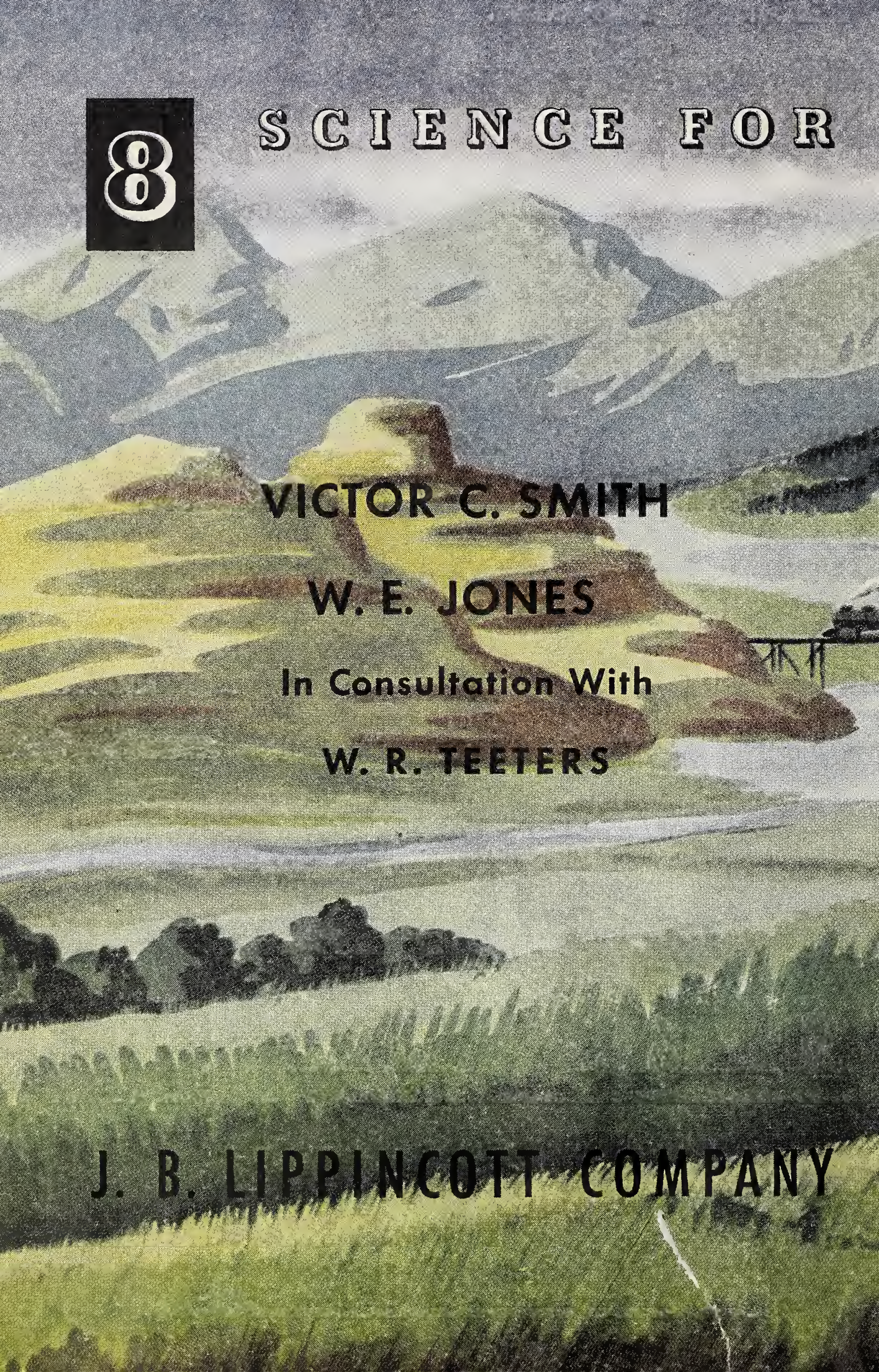
ENJOYING MODERN SCIENCE

8

SMITH · JONES

SCIENCE FOR MODERN LIVING

ENJOYING MODERN SCIENCE



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SCIENCE FOR

VICTOR C. SMITH

W. E. JONES

In Consultation With

W. R. TEETERS

J. B. LIPPINCOTT COMPANY


MODERN LIVING
Enjoying Modern Science
Chicago • Philadelphia • New York

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Enjoying Modern Science is a completely new textbook based in part upon *Enjoying Science* by Victor C. Smith and Gilbert H. Trafton.

THE AUTHORS

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Preface

B. C.

both Authors

The *Science for Modern Living Series* provides a complete general science program for grades seven, eight, and nine. It develops for the pupil an understanding of his whole environment in terms of underlying scientific principles and of their functional applications to problems of everyday living. In organization the texts provide for utilizing children's interests to stimulate learning and to solve problems by use of the scientific method.

The content. The amount of subject matter in this series of textbooks is greater than the average amount found in other junior high school science series. The interesting style, the carefully selected vocabulary, the definition of new terms as they are used, and the soundly graded experiences make possible the use of adequate informational material in the science program.

Content has been selected according to several criteria: (1) the continuing *study of syllabi* and courses of study; (2) an analysis of *current changes in the world* resulting from scientific developments; (3) an analysis of *needs, maturity levels,* and *interests of junior high school age pupils;* (4) practical *testing of new materials in classroom situations.*

The informational material is *scientific* and *functional.* While it appeals to children because of its inherently interesting nature, the text is not intended to stimulate superficial interests nor unfounded beliefs in interpreting the world of the child. Every effort has been made to develop sound scientific attitudes by example and by providing information and experience needed for scientific thinking.

The organization of the books. Each book consists of six units. Each unit is comprehensive and based upon some socially functional area of the large field of science. Each unit is introduced by an interesting pupil experiment.

Each unit consists of one or

two chapters. The chapter is introduced by a brief discussion which serves to lead the pupils and teacher into planning cooperatively a number of listed and described experiments, activities, demonstrations, and pupil reports. *Pupil-teacher planning and pupil activity are encouraged,* but the success of the following material of the chapter does not depend upon such activity.

Each chapter is divided into a number of problems. *Each problem is planned to serve as a day's program of work.* Text, self-testing exercises, and suitable teacher or pupil demonstrations make up the problem. The self-tests are of properly graded difficulty and require real study on the part of the pupil. Pupils may check their own self-tests. The teacher can assign a daily problem with confidence that the pupil will understand what to do, will be interested in carrying out the assignment, and will have means of measuring his own success in learning.

The text of each problem is continuous. That is, it is not broken up by irrelevant exercises, demonstrations, or experiments which the pupil cannot do at the moment. It does not include interpolated material which confuses the pupil. In schools where no activity or demonstration program is possible, *these texts have proved their usefulness as science readers* because of this sound organization.

Each chapter has abundant summarizing and review activities. The brief *review* of fundamental concepts and the *word list* for study emphasize major ideas of the chapter. The *exercise in thinking* is a matching exercise of *principles* and related ideas. It reviews important ideas while at the same time providing experience in seeing relations. It is useful as a pupil self-test or as a class exercise in understanding the fundamental principles derived from study of the chapter. These exercises in thinking constitute a major advance in providing means for developing an *understanding of scientific principles,* and of emphasizing understanding as a goal of learning.

If it is desired, the exercise in thinking may be administered as a test of ability to apply scientific generalizations to specific problems. Used in this way, it constitutes one of the few *valid and reliable tests of reasoning* available in the entire field of science instruction.

Both the recommended *motion pictures* and *filmstrips* and the lists of *reference books* have been carefully selected from the tremendous number available. Every film has been classroom tested and has definite value in contributing to understanding the major problems of the chapter.

The illustrations. The illustrations serve three major instructional uses. Arousing *interest* is one of these. Teaching an *understanding of details or processes* is accomplished by use of line drawings. Supplementing

and *enlarging pupil experience* is the function of most of the photographs and of many of the drawings. Many textbooks have used illustrations as a substitute for adequate text and to pad out an inadequate presentation of text material. The illustrations in this book are pertinent and to the point. Many have been obtained from industrial sources to help make science functional in a technological civilization. Others serve chiefly to direct pupil activity.

The grade placement of subject matter. A constant problem in science education is to meet the needs of pupils in terms of their maturity levels and interests, and still avoid repetition. The authors of this series have attacked this problem by extensive research involving use of objective tests to discover on what grade level the average pupil achieves a degree of mastery required to continue learning. Detailed analysis of subject matter in terms of its difficulty has made possible a sufficiently accurate grading of material to meet usual classroom needs. Thus these texts are graded on the basis of scientific measurement.

Selection of units in which to utilize detailed information has been made after careful study of child growth, syllabi, and testing materials in classroom use. Units proceed from grade to grade on the basis of complexity of underlying concepts as well as in terms of the child's maturing interests.

A complete learning program. This series of science textbooks embodies the best of tried and accepted science instructional materials and methods. The activities, self-tests, mastery tests, word lists, principles lists, visual aids, extensive references, demonstrations and experiments, and abundant functional textual material and illustrations provide a complete science program for grades seven, eight, and nine. The series is sufficient in scope to challenge the most progressive and complete city school, or it can be adapted to the needs of the meagerly equipped one-teacher school. The careful organization of reading, self-tests, and pupil activities makes possible *a minimum of teacher direction* when time and materials are limited. *This science program requires no workbook.* It is complete in the texts and teacher's manual.

The authors believe that the teacher does his most rewarding and useful work in his daily guidance of and contact with his pupils and have produced a program which will leave a major portion of the teacher's time available for actual teaching. The teacher using this series will be able to eliminate much time-consuming planning, correction of exercises, hunting for materials, working out of assignments, and other routine drudgery.

He will have the satisfaction of observing his pupils growing up, not only in general maturity but in understanding of themselves, their complex environment, and

the methods and techniques of scientific learning.

The acknowledgments. The authors are deeply indebted in many ways to their teacher friends and fellow workers. Many teachers have co-operated in giving objective tests on which grade placement of units is based. Many teachers who used the preceding *Science in Modern Life Series* have made suggestions of great value in producing this entirely new series. Many pupils have taken tests, contributed original ideas, and assisted in trying out materials in science classes. Pupils of the Ramsey Junior High School photography classes have assisted in taking pictures and by serving as models in the science activities illustrations. Many leaders in the fields of general education, science education, and curriculum construction have contributed to the basic philosophy and to the techniques on which this series of books is based.

The lists of reference books were prepared by Miss Katherine Putnam, Librarian, Bryant Junior High School, Minneapolis. The lists of films were prepared in consultation with Mr. E. Dudley Parsons, Consultant in Visual Education, Minneapolis Public Schools. The authors and publishers make special acknowledgment to the late Gilbert H. Trafton, pioneer in the field of functional science education.

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You can do this experiment. White light is made up of colored light in certain combinations. Two complementary colors, properly balanced, will serve. Obtain two lamps and some colored cellophane and set up the experiment as shown in this picture. The room should be darkened to make the colored lights show. You will observe that a shadow is produced by shutting off light, and that the shadow from each colored light shows no light of that color but shows only the color of the light from the other lamp. Where the two shadows overlap, the resulting shadow is black and shows no color. (Be careful that the cellophane does not touch the lamps or catch on fire.) →

SCIENCE FOR MODERN LIVING

ENJOYING MODERN SCIENCE

Introduction

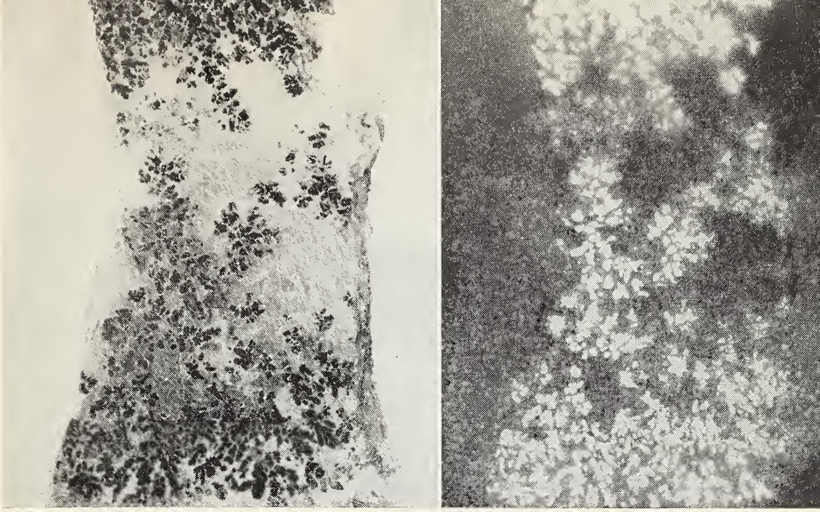
1. Can you think scientifically?

If you should see, in a novelty-shop window, a four-leaf clover in a plastic case, a rabbit's foot on a chain, a small horseshoe, and a coin with a swastika cross on it, would you be tempted to buy one of them to improve your luck? If you have studied science, you know some rules to use in your thinking about such a problem.

What is science? Science employs three different ways of learning. First, science provides a method of discovering new ideas. In the second place, it includes a method of thinking which produces correct conclusions from evidence collected. And finally, we learn from the large body of organized knowledge which has been gathered and tested by use of the scientific method.

The scientific method of learning is based upon solving problems in a certain way. After a problem is discovered, a trial answer, or hypothesis [hī·pŏth′ē·sĭs], is set up. Then the correctness of this hypothesis is tested by an experiment. An experiment is usually a method of comparing one thing with another thing in some way. Sometimes two different things may be compared. For example, to test a food one set of rats may be fed the food, while another set is fed something else. A comparison of the two groups is then made. Or the comparison may be made of the condition of a certain thing at one time with its condition at another time. The method of testing for starch with iodine shows how this is done. Starch is white before the iodine is added, and blue afterwards. Which of these methods could be used to test good-luck charms?

Even when an idea is tested it is necessary to understand what happens, and still more important to understand what causes the observed changes. To test



Ward's Natural Science Establishment, Inc.

This ore, uraninite, contains a chemical which gives off atomic radiations. At the left is a photograph of the ore. At the right is a picture made by placing the ore on photographic film in the dark. The rays from the ore made the picture. Do you want to learn about atomic energy?

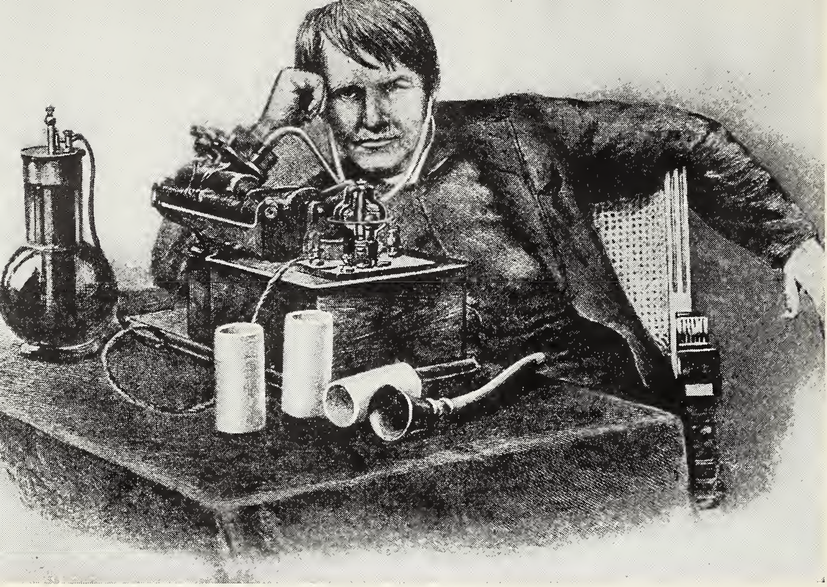
their thinking scientists have a rule called the law of cause and effect. This law is: Every effect is the result of a definite cause or combination of causes. The effect must always follow the cause. The same cause or causes must always produce the same effect. Can you test the use of charms by this law?

You must have practice in using this law to understand it.

We say that this book is a science book because it contains knowledge discovered and tested by the scientific method. Some of the information has been tested so thoroughly that it will not change. Some of the information is still being tested, but it is so useful that until more is known we should act on it. You will gain skill in understanding how scientists learn as you gain understanding of their results.

Why are some people superstitious? A superstition is an unscientific belief which some people use to explain things they do not understand. It is different from ignorance, for a person who is ignorant does not know a certain thing. A person who is superstitious thinks he knows something which actually is not true. Superstitions are generally passed from person to person. The superstitious person generally tries to frighten the one he is talking to in order to make him believe the superstition. Has somebody told you a ghost story so well that you have almost believed it?

People often are afraid of those



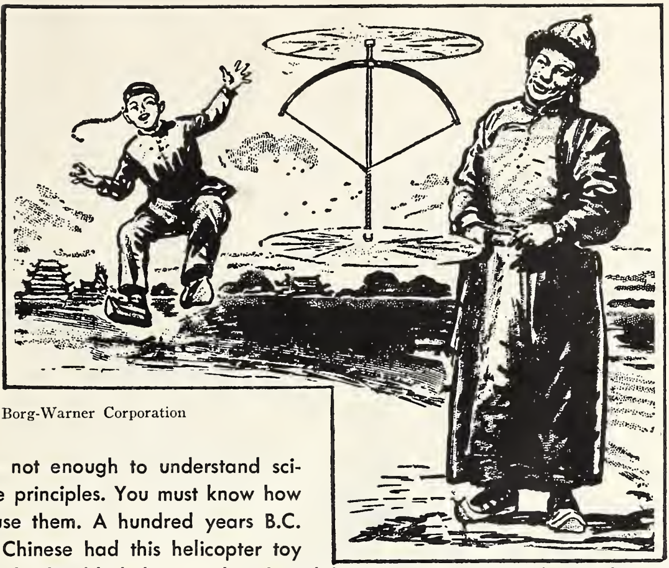
Edison Electric Institute

Thomas Alva Edison is shown listening to his phonograph. The records were wax cylinders. Note the old-fashioned battery, used to provide power for the phonograph.

things they do not understand. The things that today are explained clearly and sensibly by scientific experiment were deep mysteries in ancient times. Many matters relating to changes in seasons, weather, sickness, death, and ordinary events seemed to primitive people to be controlled by some perverse fate. Primitive people believed gods or devils were in charge of most natural events. As a result of such beliefs, ancient peoples developed the custom of trying to secure the favor of evil spirits by all sorts of bribes. Many people still try to win good fortune by doing silly things which are in no way related to the cause of good fortune.

We cannot blame the ancient peoples too much for their fears. Before the invention of the microscope, bacteria were just as hard to imagine as were devils—both were invisible. The belief that evil spirits caused disease seemed reasonable to ancient peoples. Until a definite cause-and-effect relationship was proved to exist between bacteria and disease, there was no explanation of disease much better than belief in evil spirits.

Many of our superstitions are based upon careless or inadequate observations. The idea that the changing moon causes the weather to change is such a belief. We have a tendency to draw conclusions from too few cases.



Borg-Warner Corporation

It is not enough to understand science principles. You must know how to use them. A hundred years B.C. the Chinese had this helicopter toy with feather-bladed rotors, but they did not go on to invent the airplane or a real helicopter. Could you make this toy?

Thus if one sees a person who is pale, physically weak, and very bright, he may conclude that these traits always go together. This is not the case, of course.

Some superstitions, such as the Friday thirteenth "jinx" started because of the distant past.

Another type of faulty observation results in the naming of things that do not exist. There are many purely imaginary animals described in great detail—sea monsters, combination lions and eagles. and so forth—that never existed except in the mind of a careless or imaginative observer. Imaginary relationships are named just as imaginary objects. Mind reading is believed to be such an imaginary relationship.

The idea of certain days or places being lucky or unlucky is a relationship difficult to prove.

Many superstitions are directly the result of confusion of cause and effect. Two things that happen about the same time may be cause and effect, or both may be effects of the same cause, or they may be entirely unrelated.

Most of the superstitions about luck result from confusion of cause-and-effect relationships. If a baseball player wears a certain shirt when a hitting streak starts, it is not because of the shirt that the hitting continues. Yet some players will wear the same shirt

Each picture illustrates a common superstition. Can you state what the superstition is and why it is an unfounded belief?

until the hitting streak is broken. A rabbit's foot can't change your science test, but some pupil may have a rabbit's foot in his pocket to bring him luck! In this test, such beliefs will bring failure.

Can you test your thinking? Below is a list of sentences. Some of these are superstitions, and some are statements of fact.

You can test your thinking by writing the numbers from 1 to 35 on a piece of paper. After each number write the letter **T** if the sentence is true, or **S** if it is a superstition.

After you have completed this test, it is well to discuss your beliefs. If you made many mistakes you should be especially careful

to discover why you have learned superstitions.

1. Soot on snow makes it melt faster.

2. In the spring toads seek water.

3. In planting vegetables it is important to plant them at the right time of the moon.

4. When salt is spilled at breakfast, plans for the day should be changed.

5. It is foolish to walk under a ladder, for one will have bad luck.

6. Frost forms on still, cold nights.

7. Rubbing warts with a potato will cure them, if the potato is thrown away.

8. Gypsies can tell fortunes better than other people.

9. Ghosts of those who have been murdered are more likely to return than are ghosts of those who die naturally.

10. Improper food will stunt the growth of children.

11. A winning athlete should use the same equipment to keep his luck.

12. Everyone needs a spring tonic to thin the blood.

13. You are more likely to get this wrong because of its number.

14. Winter weather can be forecast by the bark of trees and the fur of animals.

15. The ouija board often tells true events before they happen.

16. A willow stick, if properly held, tells where there is water underground.

17. People who rise early are more likely to become very rich.

18. A birthmark is caused by the mother's receiving a shock before the child is born.

19. Vegetables are necessary for proper diet.

20. Finding a four-leaf clover or horseshoe will bring luck.

21. It is more serious to break a mirror than a valuable dish.

22. Lightning never strikes twice in the same place.

23. No one can escape the curse of a dying person.

24. Very young children who are very bright seldom amount to much.

25. People generally die at about the same age their parents die.

26. A slow worker almost always does things better than a fast worker.

27. Boils are a good sign because they purify the blood.

28. A person's character shows itself in his handwriting.

29. When the Big Dipper is right side up, the weather will be dry.

30. Dishonesty shows itself in a person's eyes.

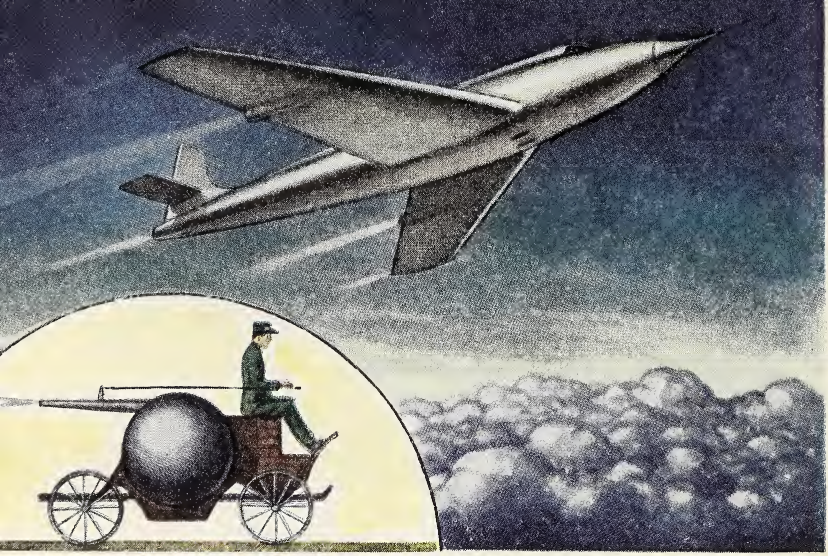
31. Genius is a form of insanity.

32. Fat people usually eat too much.

33. It is proved that people can know by mental telepathy what is happening at a distance.

34. Almost all intelligent people are physically weaker than the average.

35. The arrangement of the stars and planets when one is born determines his fate.



Newton stated the law of jet engines and tried unsuccessfully to develop a steam-jet carriage. Jet planes apply Newton's law successfully.

2. *How do scientists work?*

You may think that you are not likely to make any great scientific discoveries and therefore will not need to know much about the scientific method. But as far as you are concerned almost everything which you will learn and which is really true will be a scientific discovery. In order to know anything you must obtain and understand evidence, and must be able to draw sound conclusions from it.

When you are trying to learn how to do something, it is well to observe how some skillful person does the same thing. Observing a good swimmer makes it easier to know how to swim. There are many great scientists whose work will show us how to learn science.

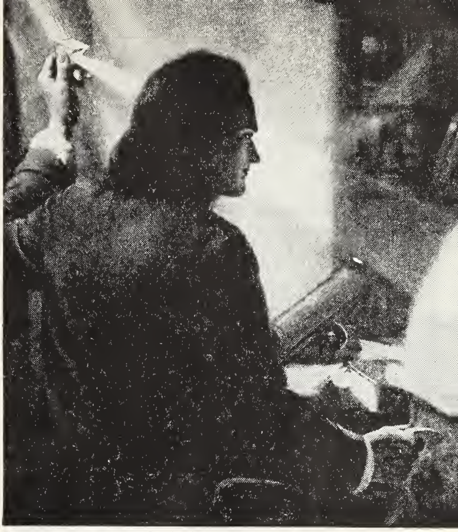
Who developed the scientific method? While many men have helped to develop the methods of science, the greatest advance was made by Galileo, an Italian who was born in Pisa in 1564. He was educated at the University of Pisa, and later was appointed professor of mathematics there.

When Galileo was a professor at Pisa, he performed the first and most famous of all science experiments. The writings of Aristotle state that heavy objects fall faster than light objects. Galileo took objects of different weights to the top of the Leaning Tower of Pisa and dropped them to the ground. Regardless of their size, the objects fell to the ground in the same length of time. The

crowd of students and professors watching were amazed to find that Aristotle had made a mistake. This experiment started a new way of learning—a method based upon testing the idea by actual experiment instead of by argument and reasoning.

Galileo also used observation as a method of learning. While he was a student at Pisa, he noticed that the lamp which was hung from the ceiling was swinging in regular time. He counted his pulse for a timer and found that the last short swings required the same amount of time as the longer swings. He realized that this type of swinging object, called a pendulum, might have value in counting the pulse of the sick. The pendulum became for many centuries the chief means of regulating clocks, a practical use of an idea developed by accurate observation.

Galileo learned in 1609 of the telescope which had been invented in Holland, and set about making a telescope without having seen one. With it he made the first observations of the bodies in space ever made except with the unaided eye. He discovered the craters [circular openings] on the surface of the moon. He also found that the planets are like the earth and not like the stars. He discovered four of the nine moons of Jupiter. By observing the motion of sunspots through his telescope, Galileo was the first to learn that the sun itself rotates. These discoveries upheld the earlier observations of Copernicus, who had stated that the earth revolves around the sun.



Bausch and Lomb Optical Company

Sir Isaac Newton holds in his hand a glass prism which is throwing rainbow colors upon the screen. Most of our present knowledge of light came from this beginning.

Galileo also developed experiments to prove that air exerts pressure, and developed proofs that water is lifted in a pump by air pressure. One of his inventions was a barometer filled with water. In this barometer a column of water 34 feet high was supported by the air. One of Galileo's pupils, Torricelli, made a more convenient barometer by using mercury in it instead of water. Galileo also invented an air thermometer which measured temperature changes.

What did Sir Isaac Newton contribute to science? Isaac Newton's discoveries carried sci-

Louis Pasteur worked in a laboratory similar to the ones we have today. He is shown observing a bottle in which he is growing disease-producing germs.

ence forward from the work of Galileo. Newton was born in 1642, the year Galileo died. He studied at Cambridge and, like Galileo, became a professor of mathematics.

One of Newton's first discoveries was that white light is not really white but is a combination of many colors. In his experiment he used a prism of glass through which he caused a narrow beam of light to pass. The beam was broken into the colors of the rainbow. Newton found a way to study each color making up white light.

The small telescopes of Newton's time were far from perfect. Their lenses separated light into its various colors in the same way that cheap field glasses do. Newton invented and designed a telescope which used a mirror instead of a lens. Newton's telescope advanced the work of astronomy far beyond the limits set by Galileo's telescope.

Newton first stated the law of gravitation. This law relates to the attraction of bodies moving through space. The law of gravity formed the first reasonable basis for explaining the motion of the parts of the solar system. It brought order to the science of astronomy.

Newton also developed the laws describing the motion of objects through space. These laws are the basis for modern transportation and for many kinds of work done by machines.

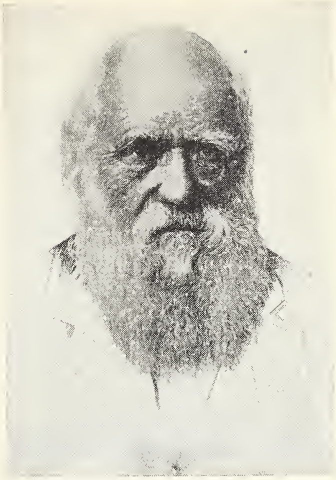
Scientists use mathematics to understand better the meaning of their observations and measurements. To the rapidly growing science of mathematics, Newton added his share to a most important part, called calculus.

What did Louis Pasteur contribute to science? Much of our present knowledge of the cause of spoilage of food and the causes of certain diseases began with the work of Louis Pasteur. Pasteur was born in France in 1822. He, too, became a professor of mathematics and was a student of chemistry. Pasteur had the advantage of having 200 years of scientific study upon which to base his work. The science of chemistry had been developed. The microscope had been in use for 150

years. During the lifetime of Pasteur other scientists made great contributions of learning.

One of the problems Pasteur was given to solve was that of preventing wine from spoiling. After careful experimentation, Pasteur discovered that fermentation and spoilage were caused by yeasts and molds. He found that heating the wine stopped the growth of these microscopic plants and prevented spoilage. Pasteur also demonstrated that foods may be kept indefinitely if they are boiled to kill germs and are sealed while hot to prevent the entrance of more germs.

One of Pasteur's most brilliant experiments was a development of a method of preventing the disease called anthrax. He knew of the development of vaccination against smallpox which had been worked out by Jenner. Pasteur learned by experiment how to weaken anthrax germs until they became harmless when put into the body of a healthy animal. These germs caused the animal to develop a resistance to the disease. To prove his success, Pasteur used two pens of sheep. Those in one pen he inoculated [ĭn·ŏk′ů·lāt, to put beneath the skin] with the weakened anthrax germs. The others he did not inoculate. Then he put the living germs of anthrax into the blood of all the sheep. Of the sheep that had been inoculated, all lived; while every one that had not been inoculated died. By a similar method Pasteur worked out a method of inoculating against rabies, a disease spread by the bite of dogs suffering from the disease.



Charles Darwin as an old man published the information which he had spent a lifetime in gathering.

What did Charles Darwin contribute to science? No other man has contributed as much to a proper understanding of living things as has Charles Darwin. Darwin was born on the same day as Abraham Lincoln. He was graduated from Cambridge University, ranking tenth in his class. Because of his exceptional ability, he was chosen as a young man to work as a naturalist on the ship *Beagle*. This ship made a tour around the world that took five years. Thus Darwin had an opportunity to collect and study minerals, plants, animals, and fossils in many lands. Earlier scientists had learned that living things are similar to each other in many ways. Although a system

of classifying plants had been worked out, there seemed to be no reason or order in the understanding of living things. Darwin developed the idea that the present complex animals and plants which live on the earth must have developed over thousands of years from simpler forms. This idea of Darwin's was not new, for it was recorded in the writings of the Greeks. What Darwin did was to study it scientifically. Whenever possible, he measured and counted everything he observed. Only after 20 years of careful study and observation did he publish his results in a book, *The Origin of Species.* Darwin's studies stimulated interest in the science of living things. Some of his ideas are the basis upon which modern life science has developed.

How has science grown? Many other men added their contributions to those of the great geniuses of whom you have read. Each added unselfishly his part to the knowledge needed to make the development of science possible and took freely of the work of others to advance his own contributions. In no other field than science is there such necessity for every man to add what he can to help the general cause. No other field than science can give in turn to mankind so much that is useful and good.

DEMONSTRATION: DO ALL BODIES FALL AT EQUAL SPEEDS?

What to use: Twenty-five cent coin, paper disk slightly smaller than coin, piece of paper about three inches square, book.

What to do: Place the coin and paper disk on a book. Stand on a chair, hold the book level with your head, and jerk the book down in such a way that the coin and paper start falling at the same time.

Place the paper disk on top of the coin, place the coin on the book, and again cause them to fall.

Place the coin and the larger piece of paper on the book, and cause them to fall.

Roll the larger piece of paper tightly into a ball, place it beside the coin on the book, and cause them to fall.

What was observed: In each case how does the rate of falling of the paper and the coin compare?

What was learned: What are two forces which seem to affect the rate at which bodies fall in the air?

Things to think about

Copy the following sentences in your notebook. Select the correct ending for each sentence.

1. The method of learning by experiment was first developed by (*a*) Darwin (*b*) Galileo (*c*) Pasteur.
2. Light was studied by (*a*) Darwin (*b*) Galileo (*c*) Newton.
3. Anthrax and rabies are controlled by (*a*) heat (*b*) medicine (*c*) inoculation (*d*) treating sheep.
4. Newton developed (*a*) a method of preserving food (*b*) the law of gravity (*c*) a telescope using a lens (*d*) life science.
5. The relationship that exists be-

tween different living things was observed by (*a*) Jenner (*b*) Darwin (*c*) Pasteur (*d*) Aristotle.
6. The colors of the rainbow are found in (*a*) a prism (*b*) a lens (*c*) light.
7. The microscope was invented (*a*) by Newton (*b*) by Darwin (*c*) 150 years before the time of Pasteur.
8. Newton's telescope included a (*a*) mirror (*b*) lens (*c*) prism.
9. Great discoveries of science are (*a*) made by one man alone (*b*) based upon the work of many men.

3. How do fake scientists work?

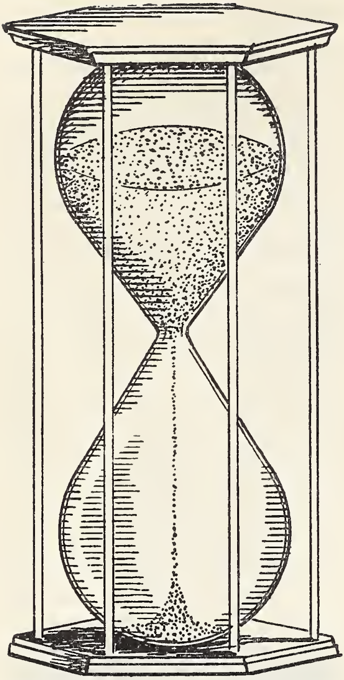
Everybody realizes that much of the everyday use of scientific words and ideas is not really correct and serious. When you buy atomic bubble gum or an electronic water gun, you know that these things are fakes. But there are many things sold seriously which are just as truly fakes as these toys. You may wonder why three million American grownups consult astrologists to learn what to do in the future, when astrology is a fake science. In many cities there are fortune tellers, palm and tea-leaf readers, and others willing to take advantage of the superstitious for a profit.

Why do superstitions continue? Superstitions continue to exist for many reasons. We still read and tell old stories which were started hundreds or even thousands of years ago. These stories are full of ignorant beliefs. Even some great literature keeps superstitions alive. Many stories are told regarding animals that talk, ghosts that walk at midnight, charms that kill people from a distance. Other mistaken beliefs are cleverly woven into the stories in ways of which you are not aware. Yet frequent repetition makes you tend to believe these stories, even though your intelligence may tell you they are not true.

There are still many grownups who have not had the advantages of learning science, and many children in school now do not study science as well or as much as they should. They obtain most of their information from unreliable sources, such as conversa-

Harold M. Lambert

Crystal gazing is generally merely an act to permit the so-called fortuneteller to mystify the victim while deciding what approach to make in manufacturing an interesting "fortune."



Although the hourglass is only an inaccurate device for measuring time, it has come to serve as a symbol of life passing away. Many such meaningless ideas are part of the stock of fortunetellers.

tions with uneducated people and reading cheap magazines and newspapers. They read thrillers based upon false but apparently scientific information about trips to Mars and life in other worlds.

Another reason that unfounded beliefs exist is that there is profit in keeping them in existence. Many fortunetellers, mediums who pretend to talk to ghosts, and readers of character make a good living from the ignorant. They do all that they can to keep their businesses alive. They frighten their customers, they promise them happy experiences, they encourage them to bring their friends. By such means these fraudulent beliefs are continued.

Probably the greatest reason that unfounded beliefs exist is that scientists, when they do not know, say so. Thus many things in the world are left unexplained, either because the question is too difficult to have been solved as yet or because it is not a true problem at all. There are many things we do not know. We do not know why babies have birthmarks. We do not know why we have long periods of dry weather. We cannot explain why people have certain fears common to everybody. We do not know just why certain diseases make us ill.

In the absence of scientific knowledge on matters difficult to study properly, the ignorant turn to anyone who states his belief as a fact, no matter how ridiculous it may be. There have been foolish stories that certain kinds of cooking utensils cause cancer, that birthmarks are caused by the mother being frightened. A story was widely circulated that the world is becoming drier because radio waves stopped the rain. It is said that because many people have the same unfounded beliefs, their beliefs must be true. Such ideas, based upon guessing, have no value but are widely believed.

Other problems which people think they have are not problems at all. They are merely foolish

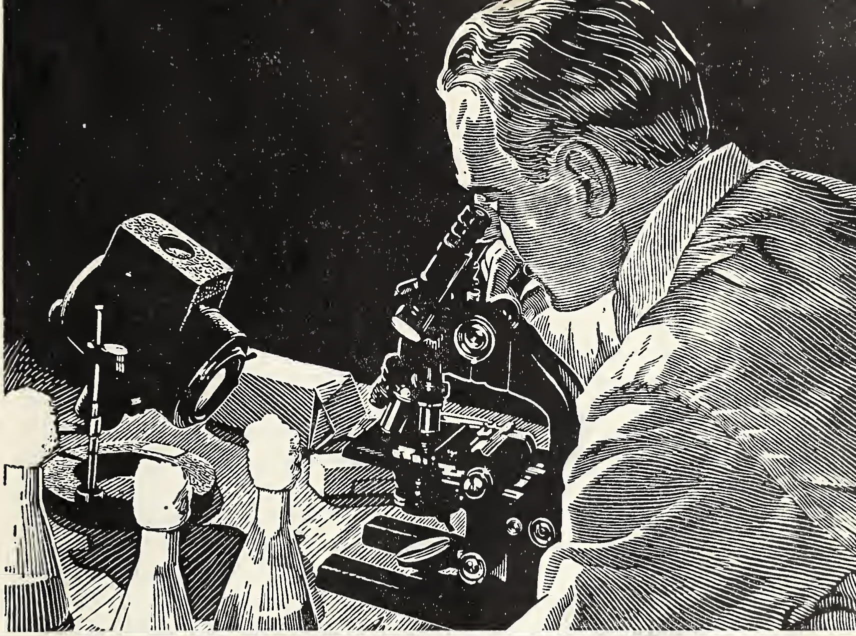
This is an astrologer's chart. As the sun passes through different parts of the sky, it is in line with the constellations in this diagram. Astrologers pretend these constellations or "signs" control our fate.

questions. Yet, if a woman wants strongly enough to know whether or not she will marry, she may pay some quack a good sum of money to tell her an answer, regardless of its falsity. It is said that millions of people regularly consult fortunetellers.

Why is all fortunetelling fraudulent? Any reasonable person knows that if he, himself, could foretell the future, he would use the information to get rich, to obtain power, or to achieve whatever form of happiness he desired. He would not have to sit in cheap houses and tearooms talking to silly people at fifty cents a fortune. Knowledge of the future in the hands of an intelligent person would give him almost unlimited power. No fortuneteller has such power.

Fortunetellers have certain tricks they use upon their customers. They listen while the customer unwittingly tells the purpose of the visit. Most people talk more than they realize, and what they think the fortuneteller told them is actually what they them-

Astronomers are scientists who study bodies in space. This picture shows how the sun would look from Mercury, the planet closest to the sun. Because Mercury has no atmosphere, its sky is black.



Swift and Company

A large part of your future depends upon the discoveries of the scientist. Scientists are not fortunetellers, but they are often able to change peoples' fortunes! This man is using the type of microscope needed to magnify bacteria many hundred times. Notice, too, the light and the cotton-stoppered flasks.

selves told under the skillful direction of the fortuneteller. Fortunetellers know that people usually come to them in trouble, most of which concerns money, their work, romance, illness, or death. Common sense makes it possible for them to guess which it is. Ability to change the conversation quickly enables the fortuneteller to cover up mistakes until he gets on a subject in which the victim is interested.

Another trick is to talk in terms so general that everybody thinks the fortune applies personally. Everyone has disappointments, takes trips, has money come to him, and is sometimes ill. A few such statements, with comments added to suit the age and appearance of the customer, make the fortune seem to mean something when it really does not.

If the victim has enough money to make it worth while, some fortunetellers actually hire detectives to find out about his private affairs, and tell him things he thinks nobody knows. The idle gossip of a neighborhood is often sufficient to make a fortuneteller seem very wise.

Why is astrology a fraud? Astrology is the system of telling

one's fate from the arrangement of the planets in relation to the constellations. This system of mistaken thinking is at least 2000 years old and may be much older than that. It is based upon the idea that when certain planets get in line, they exert forces of different kinds on the lives of people. Such beliefs are difficult to disprove, because there is really nothing there to study intelligently.

If astrology were true, all people born at the same time would be alike and would have similar fates, regardless of their parents, color, or social position. Such an idea is ridiculous.

Yet you can, by sending ten cents and your birth date, obtain a copy of the same booklet that is sent to everybody else who was born on the same date. It will contain statements of a general nature and many words that really have no meaning at all, telling what you are and what you should do to be successful.

The beliefs of astrology appeal to some people because they do not know that astrology and astronomy are not the same. Astronomy is a science, while astrology is a fraud.

Should one be superstitious for fun? Many people are superstitious and afraid of the future. They cover up their true beliefs by pretending to tell fortunes with cards or tea leaves just for fun. They say that using a Ouija [wē′jȧ] board is just a game. Such attitudes may be all right if they are honest. Few people who tell fortunes for fun are doing it only for amusement. They really hope, in spite of their intelligence, that there is something to the process, and that somehow they will get something they want.

Such silly pastimes are much less healthful than skating, playing checkers, or playing table tennis.

How can you test ideas? When you hear of some idea that sounds like a popular unfounded belief, ask these questions. Is this idea reasonable? Can it be shown to describe something that really happened? Who wants me to believe it? Why? Is the source of the information trustworthy? Is this story another form of some old superstition dressed in modern clothes? What difference does it make if this story is true or not?

Then remember that every true idea can be proved by experiment, by collecting evidence and arranging it to lead to only one conclusion, and by retesting by anybody who is interested and willing to do the necessary work.

When you learn to doubt and to check evidence, you will be on the road to scientific thinking.

Things to think about

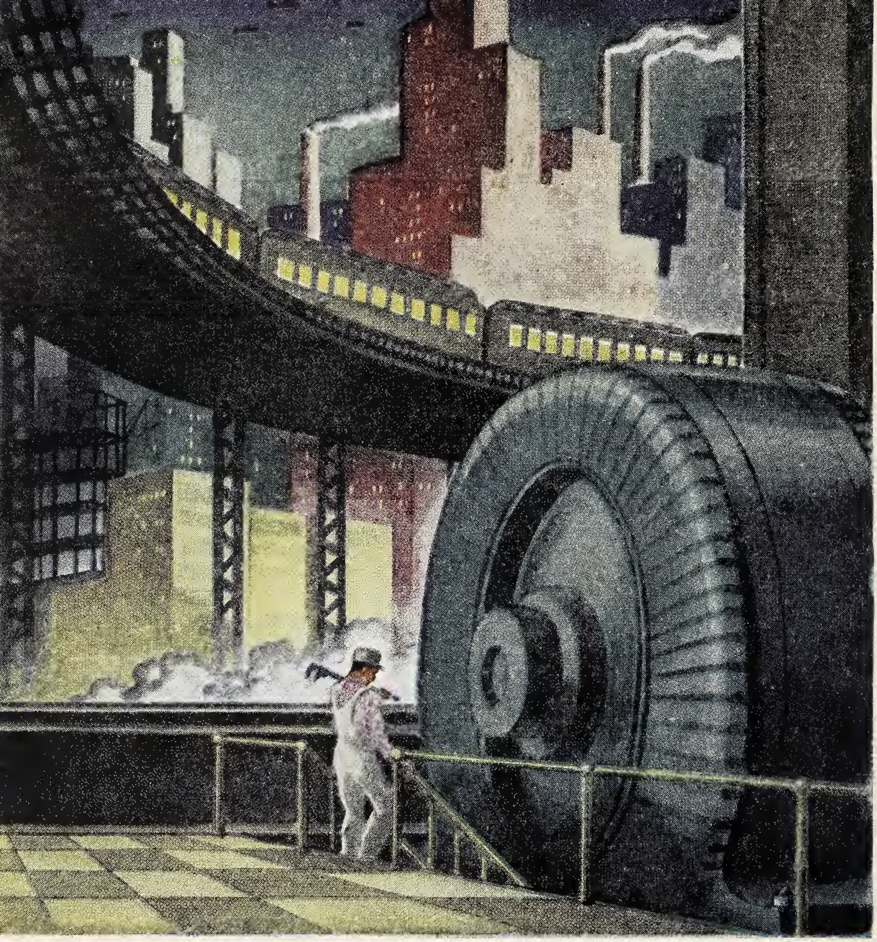
Copy the following paragraph in your notebook. Complete the sentences.

Another name for an unfounded belief is —1—. Such beliefs are common because people are —2—,

and because we read about them in our books. Some fortunetellers use faith in unfounded beliefs to obtain —3— from people. No one can foretell the —4—. Most fortunes are told in such —5— statements that they might apply to anybody. —6— is a fraudulent way of telling the future by means of the arrangement of the stars. True ideas may be tested by setting up an —7—, or by collecting —8— and drawing conclusions from it by following scientific procedures.

Some good books to read

Beaty, J. Y., *Luther Burbank, Plant Magician*
Bolton, S. K., *Famous Men of Science*
Burlingame, R., *Inventors Behind the Invention*
Burlingame, R., *Whittling Boy*
Cottler, Joseph and Jaffe, Haym, *Heroes of Civilization*
DeKruif, P., *Men Against Death*
DeKruif, P., *Microbe Hunters*
Garbedian, H. G., *Thomas Alva Edison*
Williams-Ellis, *Men Who Found Out*
World Book Encyclopedia
Yost, E., *Modern Americans in Science and Invention*



Modern cities depend upon many kinds of energy to provide for their needs.

UNIT ONE

USES OF ENERGY

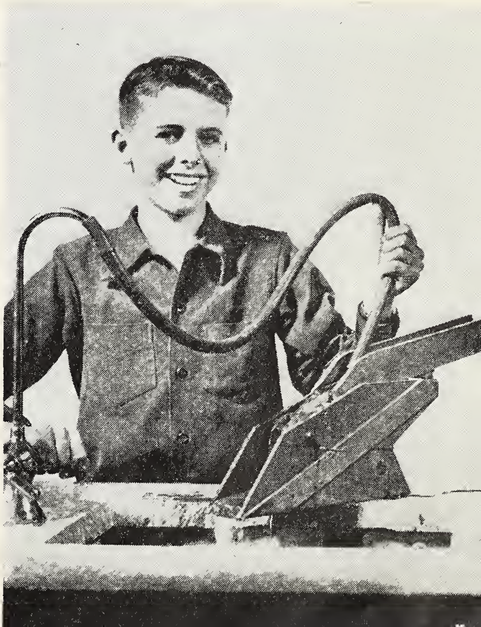
When the pupils saw John's model water wheel on the desk, they wanted to see it work. But of course they hurried to their seats to see the demonstration. As soon as the room was quiet John slipped a hose over the faucet and ran water into the trough above the wheel. The wheel spun around, splashing water as it turned.

"There are many ways of having fun with a water wheel," said John. "First I had fun when I made it at home. I used wood from an apple box. Then there is fun in showing how the water wheel works. This wheel can be used in two ways. Look!"

The trough was already adjusted so that the water fell on the top of the wheel. After running water over the wheel for a moment, John lowered the end of the trough so that the water ran beneath the wheel. The wheel immediately started turning in the other direction, but somewhat more slowly.

"There are several kinds of water wheels," said John. "This model shows you two kinds. The one I demonstrated first is called the overshot wheel. It is the kind most often used in old-fashioned flour mills and sawmills. When I run the water beneath the wheel, it becomes an undershot wheel. Such a wheel does not have as much power as an overshot wheel of the same size, because the water does not push against it with so much force.

"I was asked to demonstrate some device which showed a use of energy. The running water has energy in it. Energy can make things move. This water wheel does not have much power, but I am going to put a pulley wheel on the end of its shaft and use it to run a model mill I am making. I can put a pulley on the mill and turn it with a rubber-band belt running from the water wheel pulley. My mill will not have enough power to grind wheat, but I think it will run."



CHAPTER

1

Energy in Everyday Living

There would be no everyday living, or any other kind, without energy. Every living thing has energy which keeps it alive. But nonliving things also have energy. Even a rock lying on the ground contains several kinds of energy. Everything on earth—even a rock—contains some heat. And the stuff things are made of—matter—contains much energy. You have heard about atomic energy and atomic power. All matter is made up of atoms which contain energy.

There are some kinds of energy which we use to make everyday living more comfortable or more convenient. Some of these kinds of energy are heat, light, electricity, and sound. Each of these things can be studied in science because we can experiment with them. We cannot observe some forms of energy directly, but we can observe their effects. When you push a button and see a light come on in an electric bulb you are observing an effect of electricity. You have senses adapted for observing light and sound and some kinds of heat.

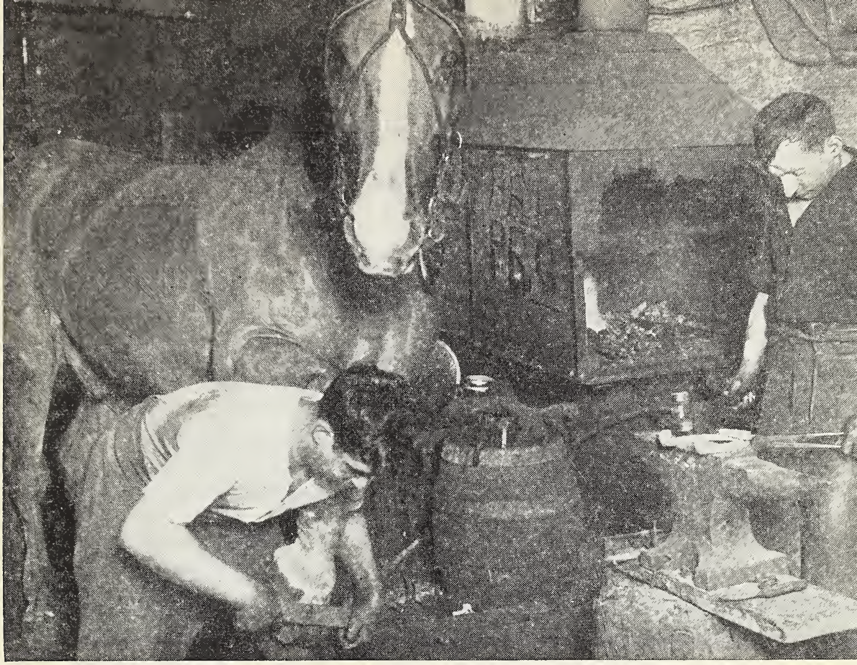
Study of energy is the biggest and most interesting problem of science.

Some experiments to do

Let us do some experiments to understand how a candle burns.

1. Light a large candle, and trim the wick to obtain a good flame. Slip a piece of writing paper horizontally into the flame one-fourth of an inch above the wick, and withdraw it before it starts to burn. Repeat the experiment, inserting the paper each time a little higher than before. Do you see wax spots on the paper? What is the hottest part of the flame? Is there a cool part of the flame?

2. Draw a glass tube 2 inches long to a jet at one end. Hold it with forceps or a wire and warm it in the flame. Then put the large, open end of the tube into the cool cone of the candle flame. Quickly light the gas which rises through the jet. Does a



Paul's Photos

In this blacksmith shop in New York City today men use methods of controlling energy to work iron similar to those learned hundreds of years ago. Note the forge for heating the iron and the hot horseshoe on the anvil.

candle flame make a gas from the wax?

3. Hold a cold metal can low in the flame. What collects on the can? Using a glass tube drawn to a jet, blow through the candle flame to make a small blowtorch, and see if you can burn the carbon from the can. Does the temperature seem to determine whether or not carbon is burned completely?

4. Hold a metal can, filled with cold water or snow, well above the flame. Lower it until you can see water collecting on the can.

5. Hold a piece of wire screen in the flame horizontally. What forms above the screen? Can you light this material and make it burn? State several things you have learned about a candle flame.

6. Make a flame of about the same size as the candle flame by lighting an alcohol lamp. Compare the flame as to the amount of carbon each produces, and the amount of light each gives off. Can you make the alcohol lamp produce more light by sprinkling powdered carbon from a match stick in the flame?

7. See how many things will carry sound. Put your ear against one end of the table while somebody taps gently on the other end. Hold one end

of an iron rod in your teeth and scratch the other end. If you can find a safe place on a railroad track, put your ear against a rail while a friend about a quarter of a mile away pounds the rail with a hammer. Can you hear two sounds? When you are swimming and your head is under the water, tap the side of the pool gently. Do many things carry sound?

8. You can hear echoes almost any time. Obtain a milk bottle, a water glass, and a pitcher. Close one ear with your finger. Hold the container about an eighth of an inch from your head over the other ear. You can hear echoes of sounds too faint to hear ordinarily. Try the other containers. Do they seem to echo the same sounds?

9. Make a model hot-air heating plant, using two cans and some sheet metal.

10. Make a fire extinguisher. Build a small fire in a safe place, and put it out.

11. Make a ukulele of a cigar box, broomstick, screws, and strings. Learn to play the scale on it.

12. Find as many strange and unusual ways of making sound as you can. Demonstrate them in class, and explain why each makes a sound.

13. Obtain some dry cells or flashlight cells, some doorbell wire, some paper, and a large nail. Wrap several thicknesses of the paper around a pencil to make a hollow tube about 4 inches long. Wind the tube with a hundred or more turns of doorbell wire. Connect it to the dry cells, which should be connected in series. Put the point of the nail inside the tube and release it. Can you shake it away from the coil? Is it magnetized? Put the nail inside the coil. Turn off the current by disconnecting a wire. What happens?

14. With a mirror look carefully at the pupil of your eyes in strong sunlight, in the light beside a window, and by candlelight. Does the pupil of the eye change in proportion to the brightness of light? Could you estimate the brightness of light from the size of your pupil?

Some subjects for reports

1. The various kinds of machines around a service station
2. How a dry cell is made
3. How static electricity is produced
4. How sunlight causes sunburn outdoors but not through glass
5. Uses of magnets in removing iron from highways
6. Edison's invention of the electric lamp
7. Faraday's experiments with magnetism
8. Faraday's experiments with a candle
9. Newton's discoveries about light
10. Changes in home lighting in recent years

1. Can you make use of energy?

You are familiar with the amazing feats of imaginary heroes in comic books. They travel through space in rockets, use ray guns and radium shields, and have supertelescopic, X-ray

International Nickel Company

Farmers constantly use energy to operate machines such as this bulldozer which is being used to clear land.

vision. But there is some difference between the world of comic books and the real world. In the real world men who work the seeming miracles of modern science must solve their problems by patient work and careful research. But the time may come when the wild dreams of the comic books are not so far removed from the real world. Scientists were able to develop the atomic age largely because of their understanding of the nature of energy.

What is energy? Although most energy is invisible, it is the most real thing in the world. It is just as real as matter—in fact, matter is composed of particles of energy. Energy has the ability to change things. It has the power of doing work and of moving things. It may be stored up or it may move at a speed of more than eleven million miles a minute. Energy is something you cannot get along without. It is something you cannot even *be* without.

Energy constantly goes through amazing changes. A ray of light given off by atomic explosions in the sun may travel to the earth through 93 million miles of cold, almost empty space. It may strike the ocean and evaporate water. The water may be carried to a

General Electric Company

One kind of energy can be changed to another. This man is using electricity to weld metal. The boxlike device is a transformer which changes the current to a more useful form. The mask is used to protect the eyes from the intense light produced by the hot metal.

mountain and fall as rain. There it may join a river which is guided through turbines. The turbines may turn generators which make electricity. The electricity may be run into a huge laboratory machine which again changes the energy into particles of matter. There are many other common ways in which energy is changed. For our purpose the most important thing to know about energy is that it can be changed from one form to another. There are several forms of energy that we can use.

Do moving things contain energy? When anything moves, it has energy in it. You have caught a fast pitched ball in your bare hands and have felt the heat and shock as the ball struck. You have seen automobiles smashed because they ran into something. Such energy of moving objects is called mechanical energy. Running water, the wind, the whirling blades of turbines, and the falling rain all contain mechanical energy.

Particles of matter, regardless of how small they are, have mechanical energy if they are in motion. The smallest particles of air are called molecules. These molecules are moving around all the time at a high speed, bumping into each other and into other things. You can feel them now. The slight pressure of air in your nose as you breathe, and the pushing in of your chest as your muscles relax both come from the force of molecules of air bumping into you.

Even smaller than the molecules are the parts of which they are made—the atoms. The atoms are made up of particles of energy with strange sounding names —protons, electrons, neutrons, and mesotrons. These particles have mechanical energy when they break out of the atom. They do not often break out, however, unless something moves them. It is easier to move electrons, which are the smallest of all particles of energy, than it is to move other parts of the atom.

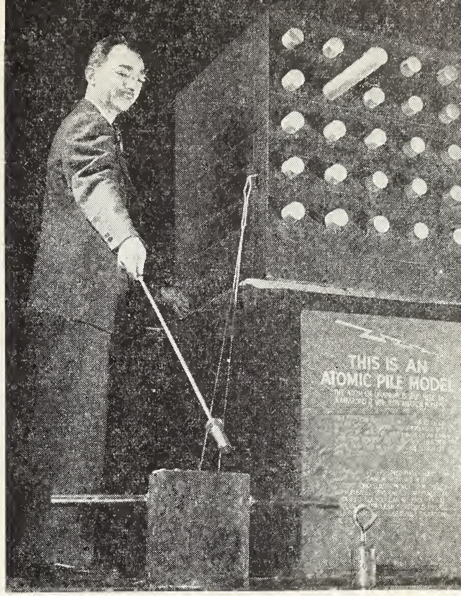
What is heat? Heat is a special kind of mechanical energy. When molecules bump into each other, they give off energy to stuff which has less of it than they do. When they bump into other molecules with more energy than they have, they gain energy. This energy of moving molecules, which can be passed from one to

another, is called heat. If you put your hand on something hot, you might feel the molecules giving energy to the molecules of your skin.

Hot objects do another thing. They set up waves that travel out in all directions. You know how you can feel warmth from a hot object without touching it. The invisible waves have a name—infrared radiation. They are not heat, but when infrared waves strike something they can produce heat in it by speeding up its molecules. Thus a hot object can give off energy that will make another object hot at a distance. Fortunately for us the sun gives off radiations which strike the earth and warm it. When the radiations from the sun pass through space, they do not warm it, for space is practically empty. These radiations produce heat only when they strike matter.

Is light a kind of radiant energy? Very hot objects give off light. Light is the form of radiant energy easiest to study, for we can see it and can see by it. We can only feel infrared energy. Light travels through space freely. It may be changed to heat if it strikes some object and is absorbed.

Do we use chemical energy? In a chemical change, one or more substances are changed into one or more different substances. Thus wood and oxygen are changed into carbon dioxide and water in burning. When a fire burns, heat and light are given off. The released energy



Brookhaven National Laboratory

The demonstrator shows how a tiny capsule of radium-beryllium mixture, valued at $12,500, is handled as it is placed in the model of an atomic pile. The capsule is contained in a metal tube at the end of the rod. It is being removed from a 150-pound lead casket used to transport radioactive substances.

was stored up in the wood. The change of matter from one form to another takes place only when the amount of energy changes. In the case of a fire, the energy is given off. But if we wish to make soap, we may mix the chemicals and heat them. They take in heat. When matter changes from one kind to another, and energy is taken in or given off, the energy in the matter or chemical is called chemical energy. It is a stored-up kind of energy.

What is electricity? We have

electricity whenever we can get electrons to leave the atoms of which they are a part and move freely to another place. Usually we get electricity from chemical changes in a battery, or from dynamos [dī′nȧ·mō] or generators. Dynamos consist of coils of wire which whirl between magnets. The magnets loosen the electrons in the moving wires. The electrons jump along from one molecule of the wire to the next. Such jumping or flow of electrons along a wire is called an electric current.

Electrons can also move through space, but they must have more energy to jump out into space than to jump to a neighboring molecule in a wire.

What is atomic energy? An atom is very tiny. Inside it are particles which are held together by very strong forces. These forces keep the electrons whirling around the central part of the atom, somewhat as the planets whirl around the sun. If the atom is jolted hard enough by some force or object, its parts separate and give off their energy as heat, gamma rays, and fast-moving particles. We have been smashing atoms only a little while because it is difficult to hit the invisible, tiny central part of the atom with particles containing enough force to break it up. Only a few elements, such as uranium and plutonium, give off particles that will smash atoms. Also machines have been invented which will do it.

DEMONSTRATION: DOES RADIANT ENERGY CHANGE TO HEAT?

What to use: Paper, heat lamp, black ink, pen, ring stand with ring.

What to do: Prepare the paper by writing three or four letters with black ink. Make the letters about half an inch high, and make the lines about an eighth of an inch wide. Dry the ink thoroughly. Set up a heat lamp on the base of the ring stand and turn on the current. Arrange the paper on the ring about two inches above the lamp, with the black letters on the side toward the lamp. Continue the heating until part of the paper is well scorched. If the paper catches on fire be careful that it does no damage.

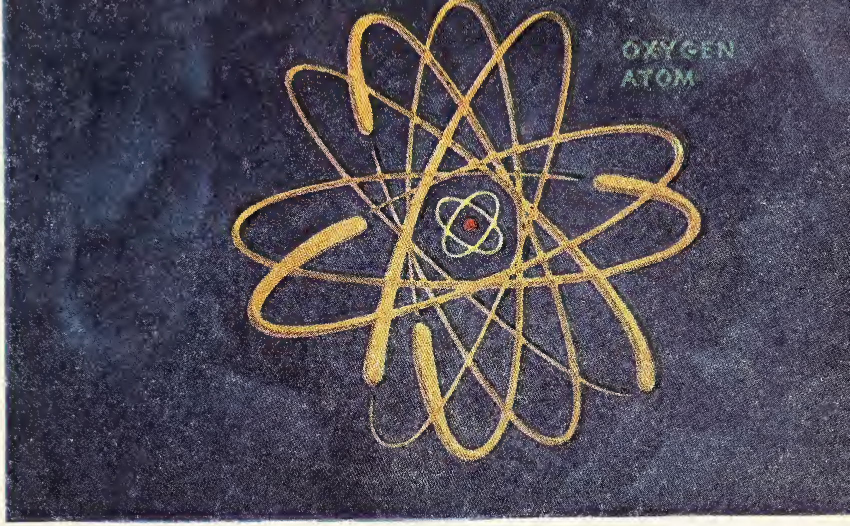
What was observed: What part of the paper showed evidence of scorching? How does heat travel from the lamp to the paper? What chemical change does heat produce in paper?

What was learned: Explain what you observed in terms of energy changes.

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

Anything that can change or move things is —1—. Moving objects have —2— energy. The smallest particles of air are called —3—. Atoms are parts of —4—. Energy that can be passed from one mole-



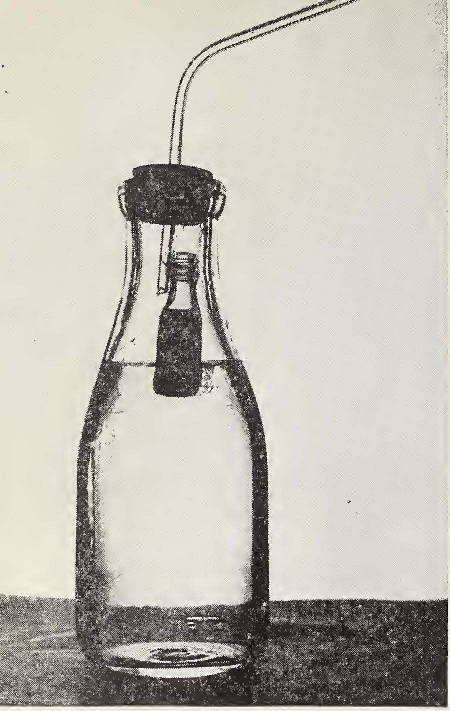
Scientists believe that the atom is made up of two or more kinds of energy particles, some of them in the center, others revolving around those in the center.

cule to another is —5—. Hot things give off waves of —6— energy. Electricity is a flow of moving —7—. When the particles which make up an atom are broken apart, they give off —8— energy.

2. Does oxidation release energy?

If you wish a simple experiment to show oxidation, just strike a match. But if you wish a more interesting demonstration, make a rocket of a paper match. Cut out a piece of strong tinfoil, about $1\frac{1}{2}$ inches square, and fold it down the middle. Put the head of the match inside the center of the fold, and lay a pin on the match, with its point touching the match head. Wrap the foil closely around the match, and withdraw the pin, leaving the space between the foil and the matchstick for a jet tube. Lay the match on a pencil, and heat the match head through the foil with the flame of another match. Do not point this tiny rocket at anything that will be damaged by being hit or burned! And be careful—always—when using matches.

What is a match? The head of the paper match with which you have been experimenting contains two active chemicals. One burns readily, and the other gives off oxygen. If the match is struck on a box which has a surface of chemicals that give off tiny sparks, the head ignites readily. In the kitchen match, the chemi-



Here is a model fire extinguisher ready to use. Note that the glass tube reaches below the mouth of the bottle. Why?

cal which starts the burning is in the small tip on the match head, and not on the striking surface of the match box.

The paper match head burns rapidly if it is in the open. If it is enclosed it makes a small explosion. Burning and explosions are two common kinds of oxidation.

Burning almost always is a chemical change in which oxygen combines with another material. The products formed by burning pass into the air. Energy in the form of heat and light is always given off by true burning.

Do some things oxidize slowly? You may have done the experiment in which you put a wad of steel wool into the bottom of a pickle bottle, which you turned upside down in a dish of water. After a few days the steel wool was badly rusted, and one-fifth of the air had disappeared from the bottle. This air was replaced by water rising in the jar. The iron of the steel wool combined with oxygen and formed iron oxide, or common rust. This experiment will work faster if the steel wool is moistened with water or, better yet, with vinegar. This experiment shows that the air is about one-fifth oxygen. The remaining four-fifths is mostly nitrogen.

Sometimes oxidation goes on fast enough to raise the temperature enough to measure. This measuring can be done by putting a thermometer inside a fairly large wad of steel wool moistened with vinegar. Heat generally is given off so slowly by rusting iron that it cannot be measured readily.

When wastes around a barn are left in a large heap, the heat given off by oxidation is generally great enough to melt off the winter snow which falls on the waste pile. Farm children are familiar with the cloud of water vapor rising above waste heaps in cold weather. The oxidation of wastes and of dead plant and animal materials, in general, is caused by the action of bacteria. The process is called decay. Many valuable things may decay.

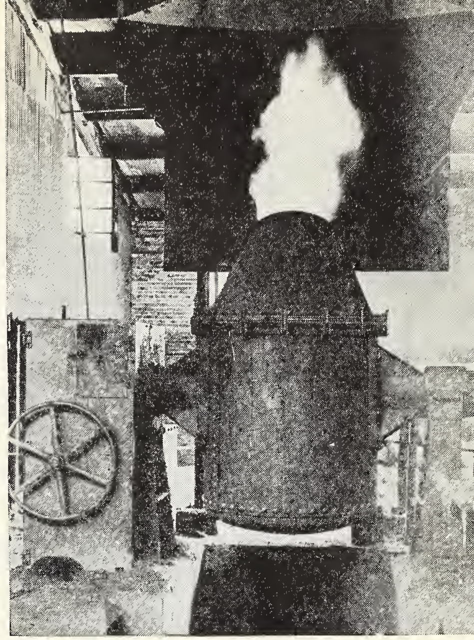
Many things combine with oxygen slowly, giving off heat. If there is no way for heat to escape, it may gradually accumulate and make the material very hot. The material may become hot enough to burst into flames. Damp hay in barns, damp coal in bins, oily rags left by painters, and oiled dust mops have all been known to start fires by slow oxidation. The burning resulting from this kind of slow oxidation is called spontaneous combustion [kŏm·bŭs'chŭn].

Can slow oxidation be prevented? Slow decay of wood and rusting of iron are often prevented by coating the materials with something which does not oxidize very much. Iron is frequently plated with such metals as tin, zinc, chromium, or nickel to prevent rusting. Wood is often painted to prevent its decay.

Paint itself oxidizes when it is exposed to air. Paint is made of oils, which combine slowly with oxygen, and of chemicals which give it thickness, color, and ability to dry. The thin coating of oxide formed by the paint, when properly formed, does not then combine further with oxygen. The tough coating of paint protects the wood from the air.

Paint may peel off if it is put on wet wood, or if moisture enters the wood from the unpainted side. But a good coat of paint put on dry wood will protect it for several years.

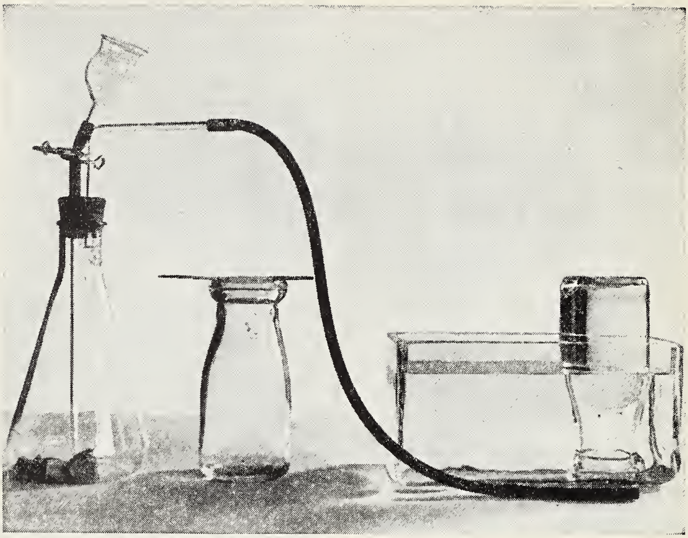
We commonly prevent decay and oxidation of food by canning it. We kill the bacteria in the food by heating it. The steam formed by cooking drives out some of the air. Cooking also drives off the oxygen dissolved in the water. Then the fruit jar is filled to the top, and sealed. Air cannot enter the sealed jar. The jar is kept sealed by the pressure of the air on the lid. The cooling of the steam and food in the jar reduces the pressure inside it. Sometimes fruit will turn brown if too large an amount of air is sealed inside the jar, even though no decay takes place.



Whiting Corporation

When air is blown into melted iron, flame shoots from the mouth of the converter. Air oxidizes many impurities in iron.

Oxidation also goes on much more slowly if the temperature is kept low. Foods left in the Antarctic by the Byrd expedition



This is the correct way to arrange the apparatus to collect oxygen from sodium peroxide. Notice that the thistle tube has been cut and a short tube put in and pinched shut with a clamp.

were fresh enough to use after several years. We use cold storage and quick-freezing to preserve many things.

Does oxidation have industrial uses? One of the most interesting and valuable uses of heat is in producing iron. Long ages ago the iron buried in the rocks was slowly exposed to the air, and combined with the oxygen to form rust. The common kinds of iron ores are all iron oxides. The method of obtaining iron from the ore is to heat it in a huge furnace called a blast furnace. In this furnace the ore is mixed with coke, a kind of fuel. The iron ore gives off oxygen which burns the coke. This leaves the iron behind. The iron flows to the bottom of the furnace where it settles, with many impurities left floating on top of the heavy, white hot liquid.

Some impurities remain, however. The melted iron is run into a large brick tank, and extremely hot air is blown through and above it. Since most of the impurities burn at a temperature lower than the burning point of iron, the impurities burn out, leaving the almost pure iron behind.

DEMONSTRATION: HOW DOES OXYGEN AFFECT BURNING?

What to use: **Sodium peroxide (oxone tablets), flask, bottles, two-hole stopper to fit flask, rubber and glass tubing, deep pan, charcoal or**

coal, wire, limewater, candle, burner, thistle tube, and clamp.

(*Caution*: Sodium peroxide forms sodium hydroxide, or lye, when wet. *Be careful not to get water from the flask on your clothes or skin.*)

What to do: Set up the apparatus as shown in the illustration. Put the lumps of sodium peroxide in the flask. Permit only a few drops of water to enter at a time. When oxygen flows from the delivery tube, collect it in the bottles. While the mouth of the bottle is still under water, cover it with a glass plate. Stand the bottles right side up. Since oxygen is heavier than air, it will run out if you do not do this. Collect two bottles of oxygen.

Tie a piece of charcoal with the wire so that it can be held in the flame. Heat it till it glows, and notice how it burns in air. Then thrust it into the bottle of oxygen. Keep the bottle covered until burning stops; then pour some limewater into the bottle.

Into the other bottle of oxygen lower a very short lighted candle. Observe how it burns.

What was observed: Did the charcoal burn much brighter in oxygen than in air? Is carbon dioxide formed when carbon burns in oxygen? How do you know? Does a candle burn with more or less smoke in oxygen than in air? In which does it burn faster?

What was learned: What evidence do you have that burning in oxygen releases energy faster than burning in air?

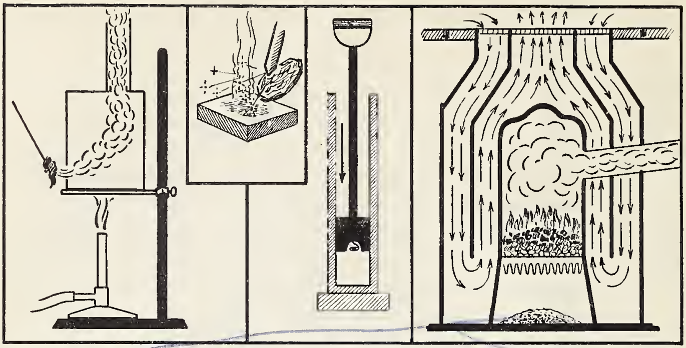
Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

The process by which various materials combine with oxygen is called —1—. Rusting of iron forms a chemical called —2—. Air is about one-fifth —3— and about four-fifths —4—. Oxidation produced by action of bacteria on plant and animal materials is called —5—. Spontaneous combustion occurs when —6— accumulates during slow oxidation. Painted wood is protected by a thin coating of materials which have already —7—. Plating protects iron from contact with —8—. Properly canned foods contain no living —9— and very little —10—. Iron ore provides oxygen which combines with —11— in the blast furnace, leaving the iron free.

3. How does air carry heat?

Air is a very poor conductor of heat, yet a large share of the heat which is carried from one place to another is carried by it. This is possible because air is constantly in motion and not because the heat is transferred from particle to particle, as is the case with a piece of iron. It is air in motion as wind that helps to keep the temperature of the world more even. Without wind, the tropics would be much hotter and the polar regions would be much



Just as a flint may be heated by striking it with a steel (*inset*) so air may be heated by compressing it in the fire syringe (*center*). The demonstration apparatus (*left*) illustrates the principle of the one-pipe hot air heater (*right*) common in small homes.

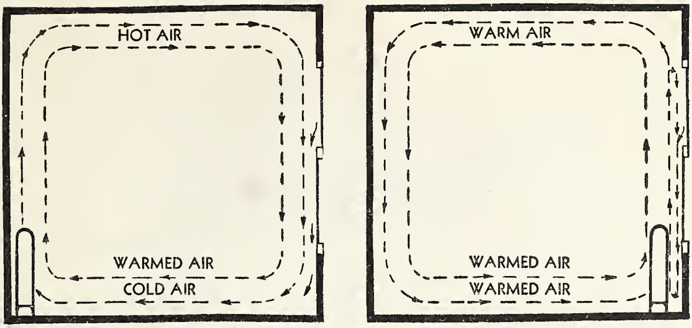
colder than they are. Moving air also carries heat from place to place in our houses.

Does air hold heat? We are all familiar with the fact that the temperature outdoors does not always remain the same. If the temperature was 50 degrees yesterday and is 60 degrees today, we know that some heat has been added to the air. Of course thermometers tell only the temperature of the air and do not tell how much heat is in the air.

A system of starting fires used before the invention of matches shows in a striking way that there is heat in air. An apparatus called a fire syringe [sĭr′ĭnj] consisted of a cylinder bored into a block of metal into which a piston was fitted. A piece of punk [partially decayed wood] was placed at the bottom of the cylinder, and the piston was thrust downward forcibly. The violently compressed air gave off enough heat to set the punk afire.

Does compressing air heat it? Before the piston of a fire syringe is forced down, the air under normal pressure contains a large amount of energy. When the air is compressed, the molecules lose energy in the form of heat, and, since the air now occupies a small space, the heat is all held for a short time close to the punk. The temperature of the punk is raised until it reaches the kindling temperature, when it bursts into flame. Use of the energy from the air to raise the temperature of punk is evidence that there is heat in all air.

How is heat held in air? We have already learned that air is one form of matter, and that it is composed of different substances —nitrogen, oxygen, carbon dioxide, water vapor, and some rare gases. Each of these gases



When a room contains a hot radiator and a cold window, the air circulates, carrying heat. Which arrangement is better for keeping floors warm? Is circulation of air in a room ever as perfect as shown in the diagrams? Why?

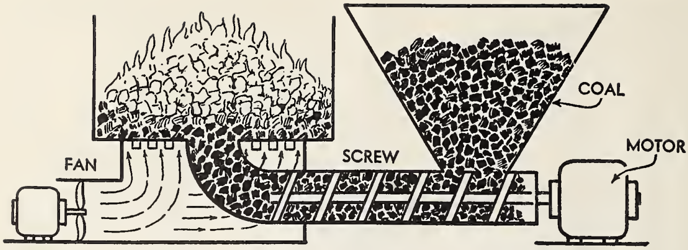
in turn is divided into small particles called molecules. That these molecules are in motion is shown by the fact that water evaporates and spreads through the air. Another proof that these molecules are in motion is that the odor of perfume reaches you in the far corner of a room when the bottle is left open, even though the air is perfectly still in the room.

In order to move, these molecules must contain considerable energy and must also be highly elastic. If they were not elastic, they would slow down after collision with other molecules and would eventually come to rest. If heat is applied to matter, the motion of the molecules increases. In this way heat energy is converted into mechanical energy.

How does heat cause air to move? When air is heated, each molecule gains energy. The molecules then bump against each other with increased force and, because of the bumping, move farther apart if they are in an open container. The result is that the mass of air expands as it is heated. If there is a supply of colder air near by, the cold air forces the warmed air to rise. As the warm air is moved by the cold air, it carries with it the heat it contains. The transfer of heat by a current of gas (or liquid) is called convection [kŏn·vĕk′shŭn].

Convection is an important means of distributing heat in the rooms of our houses. In a one-pipe, or so-called pipeless, furnace, the heat is carried directly from the furnace to the rooms. As you see in the diagram on page 34, cold air from the room flows down through an outer passage, replacing the hot air. The hot air is forced upward around the furnace into the room. Gravity acting upon the cold air provides the force which circulates the hot air in the room.

If the heat is carried into the



The advantage of a stoker is that it provides the fire with an abundance of air and feeds coal in beneath the fire so that it burns completely.

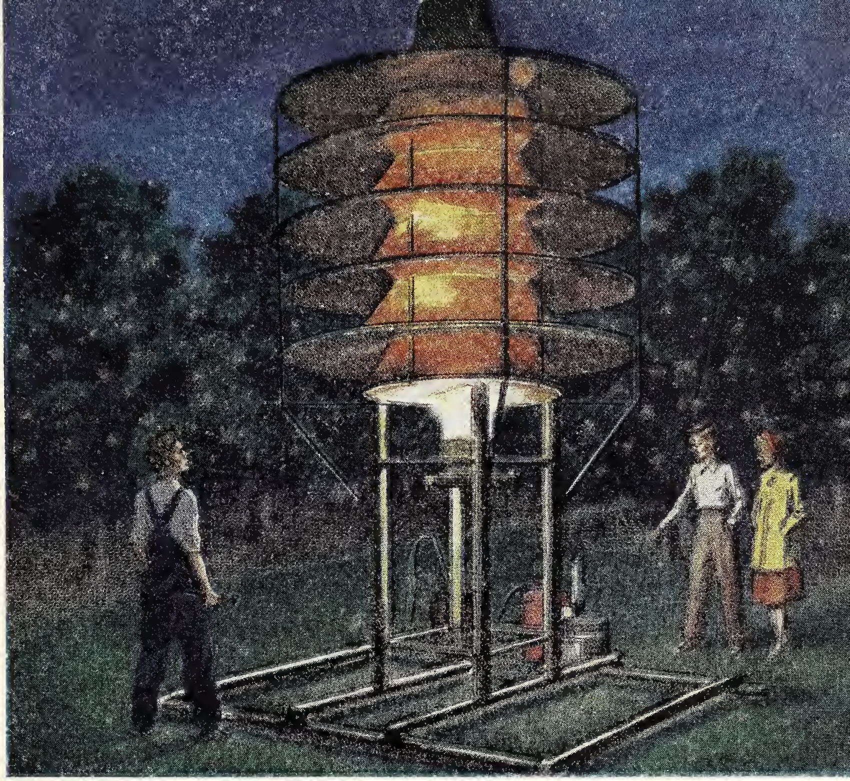
rooms to radiators, there is circulation of air in each room. The air flows upward around the radiator, and downward past the cold walls and windows. The proper location of the radiator in the room is of considerable importance. If the radiator is located beneath a window, the cold air from the window falls upon the radiator and is warmed before it circulates in the room. If the radiator is not beneath the window, cold air falls upon the floor and produces a cold draft along the floor as it flows toward the radiator.

How do we provide drafts for fires? Convection currents provide drafts for fires. But when acting alone, natural currents are rarely strong enough to provide air in sufficient quantities to insure complete burning of fuels. In an ordinary stove there is considerable waste of coal in smoke, and many unburned particles fall into the ash pit.

The furnace shown in the diagram is provided with a fan which forces an abundant supply of air through the hot coals. This type of burner wastes little fuel, and produces so little smoke that it is hardly noticeable. The device which is used to provide coal to the fire is called a stoker. It forces coal into the fire in the same way that the screw in a food grinder forces food through the grinder. To make the diagram clear, coal is shown coming from one side and air from the other. Actually coal and air are usually carried into the furnace from the same side.

The Bunsen burner and gas stove depend upon a current of gas under pressure to sweep air into the burner tubes. City gas is supplied from a large tank through underground pipes to the house.

Can energy be destroyed? You have seen that mechanical energy [the energy of moving objects] can be used to produce heat, and that heat can be used to cause air movement. You know that the heat eventually becomes lost, and you probably wonder what becomes of it. The heat of the molecules is changed to radiant energy, which is given off into



This heater protects orange groves against frost. The oil burner heats a flue red hot. The heat travels out along the aluminum disks and is radiated among the trees.

space. As the molecules lose their heat, they move more slowly. There is a scientific law which is stated thus: Energy may be changed in form, but cannot be created or destroyed.

DEMONSTRATION: HOW DOES HEATED AIR PROVIDE DRAFTS?

What to use: Ring stand and ring, burner, lamp chimney, cloth, wire, varnish can, can opener.

What to do: Cut a hole near the bottom of the can, and set it up as shown to the left on page 34. Heat the can with the burner. Tie the tightly wrapped cloth on the end of the wire and light it. Hold the smoking cloth near the hole at the bottom of the can. Hold it above the open upper hole. Repeat the experiment with the lamp chimney in place.

What was observed: How does smoke move through the apparatus? What effect has heat on air?

What was learned: Why does the air circulate through the apparatus. How is this demonstration related to the operation of a hot-air furnace?

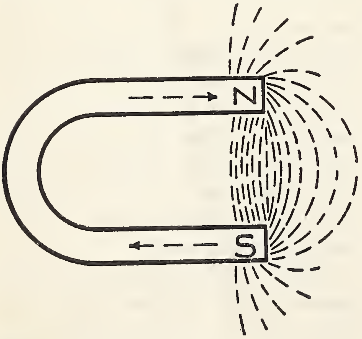
Copy the following paragraph in your notebook. Complete the sentences.

The smallest portion of matter which is like the rest of the matter is called a —1—. Heating air raises its —2—. The —3— is an important regulator of the earth's temperature. Two causes of movement of air are —4—, caused by increasing the energy of molecules, and the pull of the earth's —5—. Energy may be changed in —6—, but not —7—. The furnace gives heat to —8—, which moves through pipes into the room. The —9— gives off the heat in the room and, because it increases in —10—, it then flows back to the furnace in the basement.

4. How is electricity produced?

One of the most convenient sources of energy is electricity because electrical energy can be carried through wires or obtained from batteries which can be moved to the place where the power is needed. Because it is so easy to control devices operated by electricity, it is perhaps the most useful source of power known.

What are some sources of electricity? Electricity may be obtained from dry cells, storage batteries, or dynamos. The dry cell is made up of a zinc container which is filled with certain chemicals, some inactive substances, and a centrally located carbon rod. The materials are not really dry. The chemical action which takes place requires some moisture, but no free water need be present. The carbon rod and the zinc may have bolts or clamps fastened to them which are used as binding posts to which the wires may be attached. The electricity is produced as a result of certain chemical changes which take place within the cell, and the resulting current flows through the wires.



The direction of lines of force around a magnet may be found by use of a small compass and drawn on a sheet of paper as shown in this diagram.

Can electricity produce magnetism? Most of you have played with a magnet at some time. The ordinary magnet is a piece of iron or steel which has the property of attracting other pieces of iron. If a bar magnet is hung up by a string so that it can turn freely, one end will point north. We say that this is the north pole of the

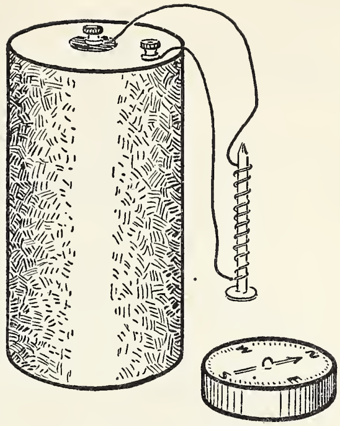
magnet. The other end which points in the opposite direction is called the south pole. A special type of magnet which is balanced on a needle point so that it can turn freely is called a compass. With such a device, one can determine the direction in which he is traveling.

When the north poles of two magnets are held together, they repel [push away] each other; but when the north pole of one magnet is near the south pole of another, they attract each other. They actually move together if the resistance between is not too great. The compass needle turns toward the North Pole because the earth itself is a magnet. The so-called north pole of the compass is really a north-seeking pole.

If an electric current flows through a wire, a magnetic force forms around the wire. If the compass is brought near a wire carrying a current, the needle turns from its normal position. This movement shows that the ends of the magnet are being attracted by a magnetic force stronger than that of the earth.

If the wire is placed in a horizontal position and the compass held above it, the compass needle will point in one direction; but when placed below it, it will point in the opposite direction. You can do this experiment with a dry cell, a piece of wire, and a compass.

The amount of magnetism around a single wire is small. To make use of the magnetism of an electric current, many turns of

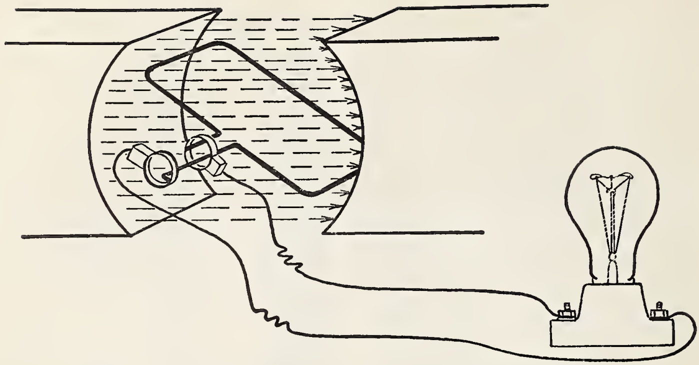


Any wire carrying a current will affect a compass needle. The effect is greatly increased by winding a coil of wire on a soft iron core.

insulated [ĭn′sů·lā·tĕd, covered with a material which will not conduct electricity] wire are wrapped around a hollow core, as thread is wound on a spool. If the compass is held inside such a coil of wire and the current is turned on, the compass needle is turned to a new position very rapidly. The more turns of wire which are used, within practical limits, the stronger the force will be.

If a bar of soft iron is placed within a coil of wire carrying a current, the strength of the magnetism is increased. Magnetism flows more readily through iron than it does through air.

How are strong currents produced? Electricity which is used in houses, factories, and trains comes from machines called dynamos or generators. The simplest dynamo you can make con-



The dynamo works on the principle that loops of wire turning between magnets may make a current. Each end of the loop is attached to a ring which slides against a metal brush connected to the wires leading to the lamp.

sists of a ring of wire which can be turned by hand between the poles of a horseshoe magnet. As the ring of wire is turned a tiny current flows around the wire. All generators work on this principle.

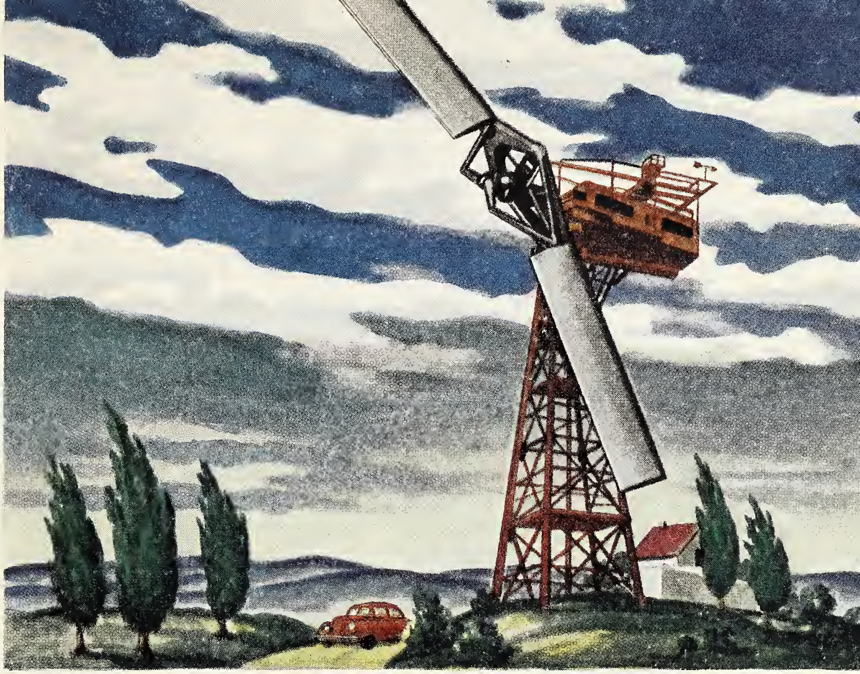
In order to make enough current for our needs, strong magnets and large coils of wire are used in making dynamos. The magnets may weigh several tons, and the wires in the coils may be miles in length. Such coils cannot be turned by hand. Instead they are turned by water wheels or engines of some kind.

An electric current is made up of tiny particles or units of energy called electrons moving along a wire. When moving, these electrons may be attracted by the north pole of a magnet and repelled by the south pole of a magnet. Some metals contain electrons which can move freely inside the metal. When a wire of such a metal is turned between the poles of a magnet, the electrons are pushed and pulled along the wire by the force of the magnet.

Such a material in which electrons can move freely is a conductor, and the best common conductors are silver, copper, and aluminum. The coils of a dynamo are almost always made of copper wire.

In order to let the current flow from the coils of a dynamo, the ends of the wire are attached to metal rings. As these rings turn they rub against metal strips called brushes, which carry the current to our house wires. Dynamos make very powerful currents. These currents are changed in strength by different devices in order to make them safe to use in our houses.

Can electricity be used safely? There are two chief dangers from electricity, fire and shock. Over-

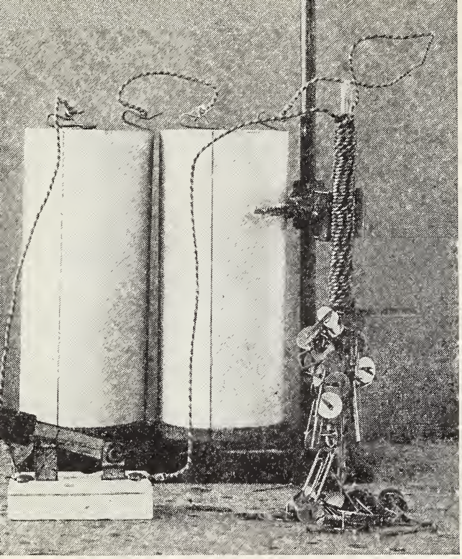


This great machine changes the energy of the wind to electricity.

loading a circuit may cause fire. The amount of current which a given wire carries determines the amount of heat produced in a wire. The amount of current which flows in the house wires depends upon how many pathways or conductors are connected between the two sides of the circuit. Each time a lamp or other electric appliance is connected between the same pair of house wires, an additional path is provided through which the electricity can flow. It is possible to connect so many appliances that the amount of current flowing through the house wires becomes great enough to heat the wire and cause it to melt.

If wire melts and breaks in two in the walls of the house it may be the cause of a disastrous fire. Even though no fire results, such a break in the wiring is generally quite expensive to repair. Because of this danger, it is customary to connect in an electrical circuit a fuse which will carry only a limited amount of current without melting. Whenever the amount of current flowing through the circuit becomes greater than the fuse will carry, a wire inside the fuse melts quickly and burns. If a burned-out fuse is replaced by some other metal—a coin, for instance—which will not melt readily, the wiring some other place may melt when the circuit is overloaded.

If one wire in a circuit is per-



This is the electromagnet which you can make. You can use it to magnetize needles for use as compasses and to magnetize hammers to hold tacks.

mitted to touch the other wire, without sufficient resistance to the flow of current, enough current flows to melt the wires. Such a condition is called a short circuit. If the insulation of electric appliances burns off, both wires may touch the same metal surface, thus producing a short circuit. If only one of the wires touches the metal, electricity may be carried through a person's body to a radiator or water pipe, which is in contact with the other wire on the ground. When a strong current flows through the body, it produces a serious shock and possibly death.

Electric heating pads are unsafe to use where they may become wet. After they are heated for some time the insulation may become cracked, and the crack may be the cause of serious burns or shock. Water heaters which operate by being put into a pan of water are rarely safe to use.

There is also danger from shock from handling ordinary appliances. To work around electric currents larger than those supplied by dry cells requires special precautions. The following statements are good rules to follow:

1. Never try to repair or handle any wire or piece of equipment which carries a current.

2. Do not touch any electrical equipment with wet hands.

3. Do not let any bare wire touch any bare metal, such as nails or pipes.

4. Remember that your vacuum cleaner, refrigerator, radio, heating pad, iron, or toaster may burn the house or kill someone from shock. Handle them with care.

DEMONSTRATION: HOW DO ELECTROMAGNETS WORK?

What to use: Dry cells, doorbell wire, large nails, small nails.

What to do: Wrap a nail tightly with the covered doorbell wire to make an electromagnet, with about a foot of wire projecting at each end. Attach the ends of the wire to the dry cell, and see if the nail will lift other nails. Disconnect it.

Make another electromagnet. Connect both, and bring them together

end to end. Observe if they attract or repel each other. Change the position of both electromagnets, end for end. Change one electromagnet, end for end; leave one unchanged. Repeat until you know which ends repel and which attract.

What was observed: How many nails can be picked up by using one electromagnet? Can you arrange two electromagnets to make them lift more than one will? Are you positive that electromagnets will repel?

What was learned: Answer the question at the beginning of the demonstration.

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

Electricity is a form of magnet —1—. Around every current there is a —2— field. A nail, a wire, and a dry cell can be used to make an magnet —3—. North and south poles attract —4— each other, but two north poles, or two south poles, attracted —5— each other. Inside the —6— of an electromagnet there is always a core made of wire —7—. When one touches a bare wire carrying a current, he may suffer from shock —8—. —9— current is one which flows in one direction. A substance which will not conduct electricity is called an —10—. magnet

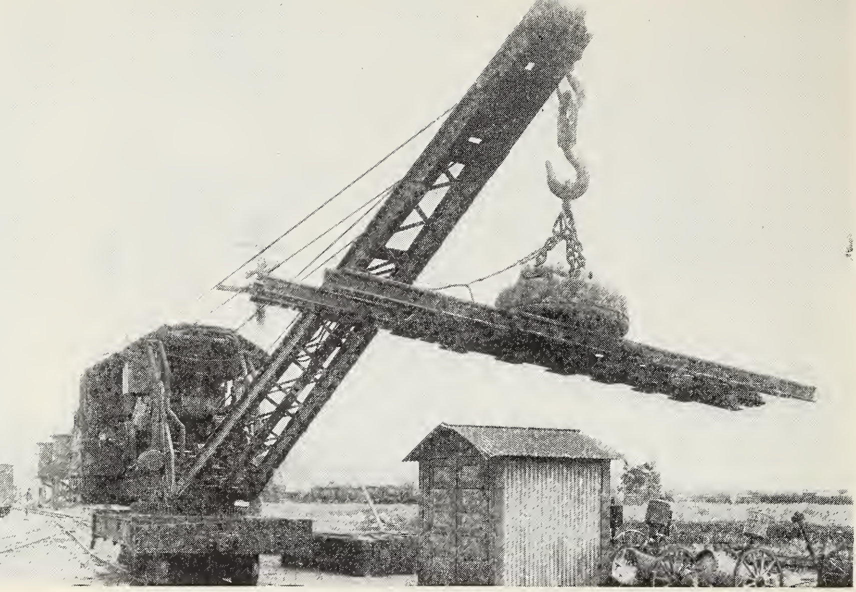
5. How is electricity used?

Electricity is the most convenient of all sources of energy for doing work in the home. Some of the devices we use in modern houses depend upon electric motors to supply force; some depend upon the use of electromagnets; and others depend upon the fact that an electric current flowing through a wire produces heat.

Can an electromagnet be used to do work? You know how to make an electromagnet. To make an electromagnet work best, you will need a source of direct current. A direct current is one which flows in one direction. A dry cell supplies a direct current which is not strong enough to be dangerous for use in experimentation. When two ends of the wire leading to the coil are at-

Pacific Telephone and Telegraph Company

The wires of your telephone conduct electricity. They do not carry sound waves.



Cutler-Hammer, Inc.

The electromagnet lifts four heavy steel rails with ease. The current is supplied by a cable supported by the small chain. Note that the steel cable which lifts the magnet is wound on a drum.

tached to a dry cell, the magnetism will be sufficiently strong to lift many small objects made of iron and steel.

If a switch is connected between one of the binding posts of the dry cell and one of the electromagnet, the current can be turned on and off readily. When the current is off and the electromagnet is placed near a piece of iron, it will do no work. If the switch is closed so that current can flow through the wire, the electromagnet will pull the iron toward it with considerable force. Moving an object through distance is work, and in this way the electromagnet does work.

An electromagnet can be made to push as well as to pull. A second electromagnet made like the first one will be magnetized when connected to a dry cell. When the poles of the two electromagnets are brought together, they are attracted strongly if they are unlike. If they are like poles they are repelled from each other. By turning off the current in one of the electromagnets, it will lose its magnetism and no longer will repel the other magnet. From this we see that an electromagnet can be used to cause another electromagnet to turn away from it.

An electric motor consists of two sets of magnets. One set is firmly attached to the base. The other set is attached to a shaft,

The electric motor has many household uses. In these pictures you can see how it developed from an experiment in magnetism (*top left*). The simple motor (*top right*) developed into the motor in use today (*middle right*). In this form it is used in the electric fan, food mixer, and vacuum cleaner.

and it is rotated by the attracting and repelling forces set up by the magnets. The outer, rigid magnets are called field magnets; the rotating magnets are called the rotor. Electric motors are the most common source of power in most homes.

How can a permanent magnet be made? The ordinary method of magnetizing a piece of iron, such as a knife blade, is to rub a magnet over its surface. Such a magnet may soon lose its magnetism. However, a magnet can be made quite permanent by rubbing a piece of hard steel with the end of an electromagnet, or by inserting it into a coil consisting of many turns of wire. In the latter case the steel should be tapped with a hammer to help the molecules of steel adjust themselves to the magnetism. If the magnet is made by rubbing steel with the end of an electromagnet, the strokes should always be made in the same direction and with the same end of the electromagnet touching the steel.

How are simple magnets used? Because electromagnets are much stronger than permanent magnets and can be turned on and off, they have many more uses than simple magnets. Permanent magnets, however, may be used in many ways. If you magnetize a darning needle and thrust it through a cork, it can be used as a compass when placed in some water. Such a compass can be used to test wires to see if they are carrying a current and to find the direction of the north magnetic pole. It also can be used for many other experiments with electricity.

Sometimes tack hammers are magnetized so that a tack will stay on the head of the hammer. To use a magnetized tack hammer, a tack should be placed on the head of the hammer and driven with one blow. Magnets are used in hairdressing establishments, also, to remove hairpins from women's hair.

How are electric motors used? When we consider the work it does, the electric motor is in many ways the most remarkable machine ever made. The largest motors made provide power to pump water in the Grand Coulée irrigation project, while the smallest motors built will fit into a thimble. Tiny motors are used in dentists' drilling tools. Trains are operated by power from electric motors.

Many of the common household machines obtain their power from electric motors. The electric fan is a motor and fan. The vacuum cleaner contains an electric fan in the nozzle of the cleaner. The washing-machine motor lightens the heavy work of washing and wringing out the clothes. An electric motor operates the pump which forces oil into the firebox of an oil burner, and operates the fan which provides the draft for the fire. Coal stokers are operated by electricity. Electric clocks contain tiny motors. Food mixers and hair driers depend upon electric motors for their power.

In many industrial plants electric motors have replaced other sources of power. In old-time factories steam engines turned long shafts from which many belts were run to operate machines in various parts of the factory. There was constant danger of a belt slipping from its pulley and injuring someone. Time was lost in replacing and in repairing belts. The belts were in the way of easy movement. Modern machines are operated by electric motors built into the machine.

How is electricity used to produce heat? Whenever electricity flows through any material, some heat is produced, because all substances resist the flow of a current to some extent. An electric circuit is made up of a complete system of wires without any breaks in it. In any circuit the different wires which make it up have different resistances. The wire which has the greatest resistance in any circuit becomes the hottest. For example, let us study the toaster. The wire in the toaster and the wire in the cord make up this particular circuit. The cord wire, which is of copper, offers comparatively little resistance to the current and remains cool. The heating unit in the toaster is made of a more resistant wire, and becomes quite hot.

The tiny filament which glows in an electric lamp bulb is made of resistance wire. While it is not designed to produce heat, it must get hot to give off light. The wire is so hot that it would burn if there were any oxygen in the bulb. Small lamp bulbs are generally made by pumping out most of the air, but larger bulbs are filled with nitrogen and other gases that will not combine with the filament of the bulb.

The electric iron is another device employing resistance wire. The wire most commonly used is nichrome [nī′krōm], the same kind of wire that is used in toasters. Nichrome is a metal made up of a mixture of iron, nickel, and chromium. The nichrome wire becomes so hot that it must be shielded with insulation to prevent it from heating parts of the iron which might cause severe burns. Insulation is also used in the iron to prevent the wire from carrying current to the outside of the iron and causing dangerous shocks. The insulated heating element is placed between two heavy pieces of iron, one of which forms the shoe, or bottom, of the iron. By locating the heating element properly within the iron, it is heated evenly.

Some irons are made safer to use by means of a thermostat [thûr′mȯ·stăt]. When the iron becomes as hot as is safe, the current is automatically turned off until cooling takes place. As the iron cools, the current automatically turns on before the material becomes cooler than needed. Irons without this safety device should be operated with a pilot light attached in the circuit so that one can see the light if the current is on.

Electrical heating devices are not machines—that is, they do not apply force to do work. They do, however, make it more convenient to do work in many ways.

DEMONSTRATION: WHAT IS THE PRINCIPLE OF THE ELECTRIC MOTOR?

What to use: Electromagnet, large needle, cork, dish.

What to do: Connect the electromagnet. Magnetize the needle by rubbing it on the electromagnet, stroking it always in the same direction. Test the needle for magnetism by picking up small iron objects. When it is strongly magnetized, thrust it through the cork, and float it in a dish of water.

Hold the electromagnet some distance above the needle, and make it turn around and around. Change the electromagnet, end for end, and make the needle turn.

If the magnetized needle is removed from the presence of the electromagnet, it points north and south, acting as a compass.

What was observed: Does the electromagnet repel the needle as well as attract it? Can the push and pull of electricity be used to produce motion?

What was learned: Answer the question at the beginning of the demonstration.

Things to think about

Match the following subjects and predicates. Copy the sentences in your notebook.

Subjects

1. Like magnetic poles
2. A large generator
3. The electric light
4. An electric current
5. The shoe of the iron
6. Unlike magnetic poles
7. A light bulb larger than 75 watts
8. Electromagnets
9. Nichrome wire
10. A fuse wire

Predicates

A. is filled with gas.
B. can produce electricity cheaply.
C. uses heat to produce light.
D. offers high resistance to current.
E. is used to conduct heat.
F. melts to protect the house-wiring.
G. attract each other.
H. provides energy in convenient form.
I. are always used in electric motors.
J. repel each other.

6. How do we use sound?

We live in a world of sound. The crowing rooster, the chime of the clock bells in the courthouse tower, the warning noise of the automobile horn, the shriek of the fire siren, the clatter of the elevated train—all these are definitely a part of our environment. Some sounds are perhaps not desirable, but what a strange world it would be if all sounds disappeared. We hear sound because of the air.

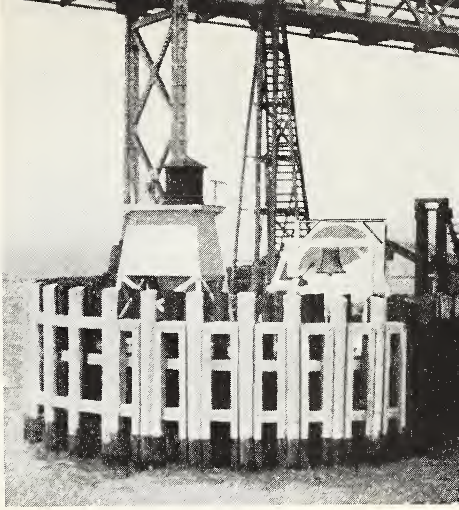
How are sounds made? Any

object which can be made to vibrate [vī'brāt, to move back and forth] at the proper rate will produce a sound. Vibrations occurring at the rate of about 16 per second will make a sound which can just barely be heard. A good human ear can sometimes hear vibrations as fast as 20,000 to 30,000 per second. Voices in ordinary speech have a range between 50 and 8000 vibrations. Very few sounds that we hear are the result of vibrations at one rate alone, but instead consist of combinations of vibrations.

There is an interesting whistle which can be adjusted to make a tone of more than 39,000 vibrations per second. Such a tone cannot be heard by human ears, but a dog may be called by it. The ears of a dog hear higher tones than ours do.

The mere fact that a vibration has been produced is not enough, however, for us to hear the sound. There must be some way by which the vibration can be carried to our ears.

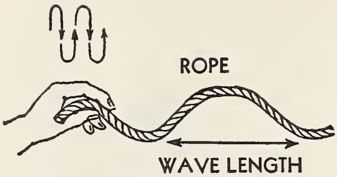
If a stretched string is caused to vibrate, the sound may be heard at a certain distance away from it. If you walk around a vibrating string, keeping just close enough to hear it, you will travel in a circle. This shows us that the sound goes from the string in all directions and with the same degree of loudness. If a board composed of loosely pressed materials is placed on one side of the string, the sound may not be heard on that side. This shows that some materials will not conduct sound.



Bells and foghorns are used in harbors to warn ships of danger and to guide them to their piers. Note that behind the bell there is a reflector which directs the sound waves out over the harbor.

On the other hand, if the vibrating string is beside a very solid material, the sound may be stronger on that side. Have you noticed that when the wind is blowing away from you some sounds, ordinarily heard, do not reach you? The air, then, must have something to do with carrying the sound from the vibrating string to your ear.

How does air carry sound? When you toss a stone into water, the ripples spread away from it in regular circles. The stone disturbs the water in about the same way that a vibrating string does the air. A wave is produced in a circle about the point at which the stone entered the water. Each wave is followed by a trough



While sound waves are not just like waves in a rope, you can see how a wave in a rope travels and understand the reason waves are of different length.

which is moved out by the formation of another wave. Such waves are formed in the air, but of course they cannot be seen. The waves in air which form sound travel in all directions, and not just along a surface as water waves do. The wave consists of compressed air, and the "trough" consists of thin air.

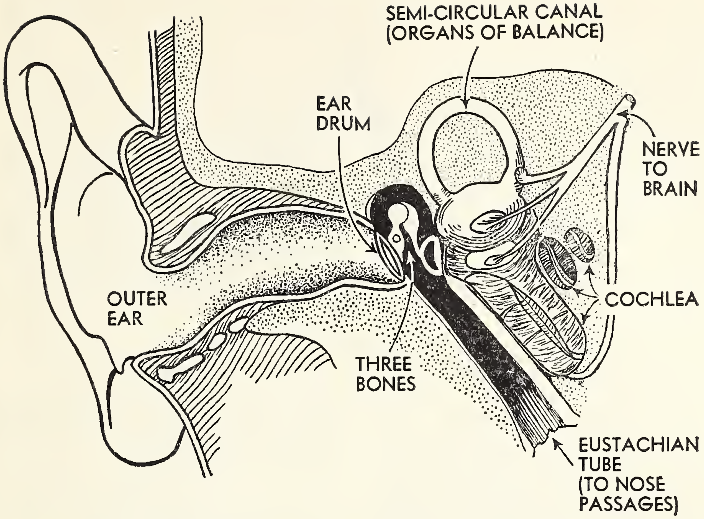
You can get an idea of how one kind of wave travels by fastening a rope at one end and holding the rope loosely at the other end. A quick up-and-down movement with the hand will make waves travel along the rope. The parts of the rope do not actually travel from your hand to the other end, but only move up and down to make the wave motion. Similarly, a cork floating on the water where waves are set up by a pebble moves up and down and does not travel away from the point at which the pebble entered the water.

When a wave travels in air, the molecules of air do not move up and down. Instead, they are pushed away from the vibrating object. When they strike other air molecules they bounce back. Thus each wave consists of a moving layer of compressed air, followed by a layer of thin air. The sound wave travels about 1090 feet in a second in air.

How do vibrations become sound? Even after vibrations are created, there is no sound until they reach the ear.

The human ear consists of three parts: the outer, middle, and inner ears. The outer ear is an irregular funnel-shaped organ which catches and guides sound waves into the middle ear. The middle ear is a tube across which is stretched a thin membrane [mĕm′brān]. This membrane is known as the eardrum. As it is moved by the sound waves, it vibrates at the same rate that the object did which started the sound wave. Behind the drum are three bones which are moved by the eardrum and carry the vibration to the inner ear. Here there is another drum which seals a coiled tube that is filled with liquid. This tube which is shaped like a snail shell is called the cochlea [kŏk′lē·ȧ]. The vibration compresses the liquid, and these compressions are picked up by the nerves of the ear which have endings in the liquid. The pressure on the nerve endings is changed into sound by the brain.

Why do we see things happen before we can hear them? As you watch a workman at a considerable distance from you striking a nail with a hammer, you notice that you do not hear the sound of the blow until he lifts

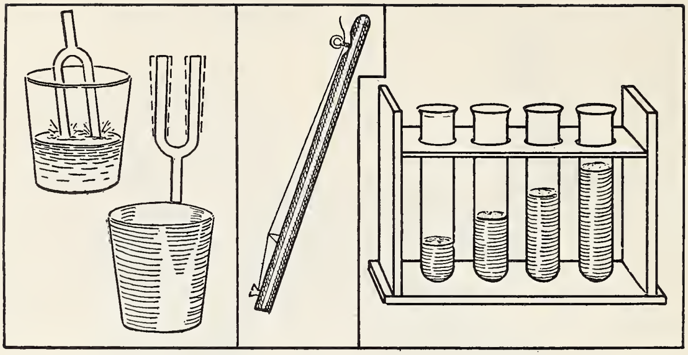


The energy of sound is transmitted from the drum through the bones of the middle ear to the container of liquid (cochlea) in the inner ear in which the nerves of hearing are located.

the hammer high in the air ready for the next blow. We see the movement of the hammer by means of light rays which come to the eye, just about as we hear a sound from the waves formed in the air. However, light waves travel more than 186,000 miles in one second, while sound waves in the same second travel only 1090 feet. That is, while a sound wave is traveling one foot, light travels almost 170 miles.

It is possible for you to estimate how far away an object is which you can both see and hear. To do this, find the length of time that passes between the moment that you saw the cause of the sound and the time that you heard it. You can estimate the time by counting "one—and, two—and, etc." for each second. Allow one-fifth of a mile for each second.

How do we speak? Air is used not only to carry sound, but also to produce it. The voice is produced by vibration of the vocal cords which lie in the throat. The air is forced from the lungs by the muscles of the chest and diaphragm [dī′ȧ·frăm, a muscle underneath the lungs, stretching across the body cavity] through a tube to the mouth. At the top of this tube is a container in which are the vocal cords. In normal breathing they lie out of the current of air. When one speaks, the vocal cords tighten so that they stretch across the air tube, and are vibrated by the air passing between them.



These drawings show how the apparatus is set up for the demonstration.

The different words are formed by the movement of the teeth, tongue, and lips. Pitch depends upon the tightness of the vocal cords. Loudness depends upon the pressure of the air as it comes through the space between the cords, and upon the formation of the bones of the head which vibrate and increase the strength of the sound. The longer vocal cords of men vibrate more slowly than do the shorter vocal cords of women and children and produce sounds of lower pitch.

The idea of vibration of bones of the head may be shown by studying the singing glass. To make a glass "sing," a tuning fork is struck lightly to make a tone, and the handle is pressed against the rim of a water glass. The vibration of the fork makes the glass vibrate with a sound that can be heard all over the room.

DEMONSTRATION: HOW MAY SOUND BE PRODUCED?

What to use: Tumbler, tuning fork, strong stick, screw, screw eye, wire string, test tubes, rack.

What to do: The demonstration is illustrated by the diagrams above. Strike the tuning fork against your heel, and dip it into a tumbler of water. Strike it again, and press it on the rim of a dry tumbler.

Make a one-stringed musical instrument, and see if you can change the tones by tightening and loosening the string. Also slide the bridge (the V-shaped support) back and forth. Pluck the string.

Fill the test tubes with water as shown. Blow sharply across the mouths of the tubes one at a time by holding your lips tightly together, then letting the air "pop" out.

What was observed: How many ways of producing sound do you know? What kind of object produces sound? How can you change the tone of sounds? The loudness?

What was learned: What is sound? What produces sound? Why are sounds of various tones?

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

When a starter of a race fires a gun, the timer should keep time from the —1— of the gun. Sound waves are produced only when objects —2— at a certain rate. Sound waves are caused by differences in —3— pressure. We hear tones which vibrate the ear —4—. A steam whistle from which steam is escaping can be seen —5— seconds before the sound is heard 2180 feet away. The voice depends upon vibration of the —6— by a current of —7—. We form —8— by movement of the teeth, tongue, and lips.

7. How do we use light?

We see best in the daytime by natural light. But because much of our work cannot be done outdoors by natural light, we use windows in our houses to let in light. We also use much artificial light. It is said that if an average family used candles to produce as much artificial light as is produced by electricity, the monthly bill for candles would be about $350. Whether this estimate is just right or not, it shows how much we have come to depend upon artificial light.

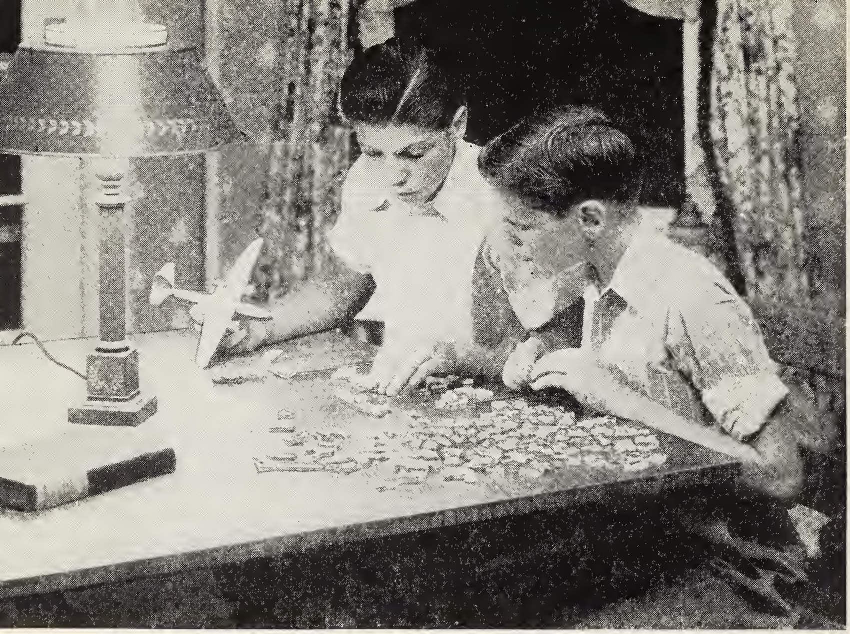
What are the common sources of light? Daylight comes from the sun. The color of sunlight is yellow white. The color of light from the sky is slightly blue. Our eyes are best adapted for seeing by natural light, and soon become tired if we use much color in artificial light.

Many people still must depend upon oil lamps for light. Common lamps burning kerosene give off a dim yellow light. In some lamps either kerosene or gasoline is used to heat a mantle, a kind of mineral screen, so hot that it gives off a yellow-white light.

Electricity is used in many lamps. The common electric lamp bulb contains a wire or filament which gives off a yellow-white light when heated. Light from most such lamps is considerably more yellow than sunlight. The newer type of lamp, the fluorescent lamp, is a tube containing a very thin gas. The tube is coated with a mineral paint inside. This paint glows when electricity runs through the gas in the tube. Fluorescent lamps may be used to provide a variety of colors, but only white or daylight should be used for ordinary lighting. The lamps producing colored light are used for decoration.

Electricity is the most convenient source of artificial light and, if it is properly used, is the safest.

Does light give things color? If you blacken water in a pan with ink, and place it near a window it will reflect light from the sky. Do not put it in direct sun-



Westinghouse Electric and Manufacturing Company

This good lamp spreads light over the table on which the boys are working.

light. If you put a drop of machine oil on the water, you can see many colors on the surface. Blowing on the oil will change the colors. This simple experiment shows that you can get color from light. The drops of rain that separate light into the colors of the rainbow produce a similar effect.

Things which have color get that color from light. The reason that all things do not look white in light is that many of them absorb some of the colors in white light. The color of the object is the color which is reflected. A red book absorbs all the colors except red. If you look at a rainbow carefully, you can see the colors red, orange, yellow, green, blue indigo, and violet. (Initials of these colors spell Roy G. Biv.) Any object that is pure color reflects all the other colors in this list. Some things reflect more than one color of light, however.

How bright should good light be? We can see by very dim light, but we cannot see well unless light is fairly bright. If we want to know how bright a light is, we must have a unit of measurement. Such a unit is the amount of light a large, standard-sized candle will give at a distance of one foot. This unit is called the foot-candle. For reading and for most indoor work we can get along for a while with five to ten foot-candles of light. For comfortable seeing for a

Owens-Illinois Glass Company

This pair of large windows admits plenty of light without leaving the room open to outside view. The windows are made of glass block.

longer time we need about 30 to 50 foot-candles of light.

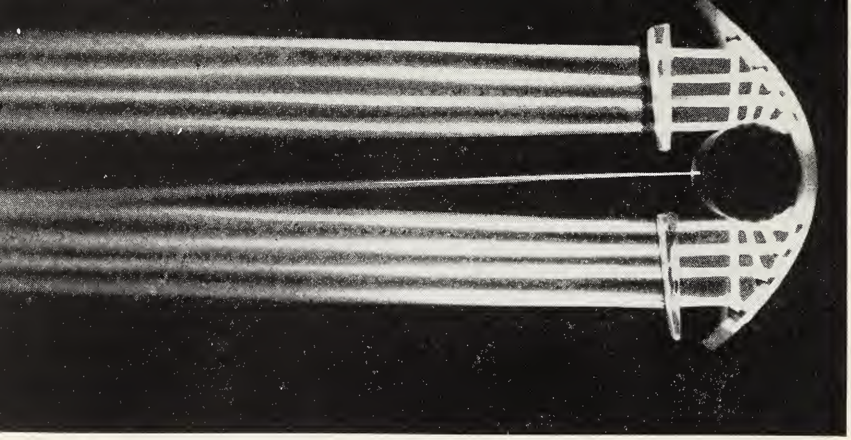
The brightness of light decreases rapidly as we move away from a lamp. Compared to the brightness at a distance of one foot, the brightness of light at two feet is one-fourth, at three feet is one-ninth, at four feet is one-sixteenth, at five feet is one twenty-fifth, and at ten feet it is only one-hundredth as bright as at one foot. Can you see any rule to fit these numbers?

Thus for good seeing we must have a fairly bright light quite close to our work. For indoor daytime work we should be close to a window.

We should not have a bright light reflected from our work. Sunlight shining on a book page, a varnished floor, or any ordinary surface may reflect so brightly in the eyes as to cause serious strain. Light shining directly into the eyes is called glare.

We should not let shadows fall on our work. An indoor shadow may be only a tenth as bright as areas not in shadows.

What conditions give good light? If we want to make good use of light, we should make the interiors of our houses light in color. The usual dark furniture and rugs absorb much light. Tan, light gray, and very soft tints of colors do not absorb so much light as do darker colors. Our



General Motors Corporation

This photograph of light rays shows that they travel in straight lines, but that they can be bent by reflectors and lenses.

walls should have pleasantly tinted, light colors. Large colored patterns on the walls absorb light and make seeing more difficult. Ceilings should be white to reflect light on our work.

We should keep shades at the top of the window and all glass bare of curtains to get the best use of daylight, except when the sun is shining directly on the window. We ordinarily should not have porches, awnings, or drapes over our windows. Large windows let in much more light than small windows.

It is particularly important to have good light where there is danger. The workbench, the kitchen work table, the bathroom, and stairways should be well lighted and should be surrounded by walls painted with soft, light colors.

Using plenty of light under proper conditions may save your eyesight. Using enough light in dangerous places may save your life.

DEMONSTRATION: WHAT COLORS ARE FOUND IN LIGHT?

What to use: Pan, water, mirror, sunlight or a projector, large cardboard.

What to do: Find a sunny window. Cut a slit about 2 by 4 inches in the large cardboard. Fill the pan completely full of water. Stand a mirror in a slanting position in the pan. Now put the cardboard in the lower part of the window and lower the shade to the top of the cardboard. Put the pan in such a position that the beam of sunlight (or light from the projector) falls on the mirror. By slanting the mirror just right you can produce the colors of the rainbow on the wall beside the window, or on a white paper. This band of colors is called the spectrum.

Hold different colored objects in the spectrum. Observe any change in brightness as the spectrum falls on the colored objects.

What was observed: What colors can you see in the spectrum? What colors are absorbed or made duller by a red object? A blue object? A yellow object? Do you see any evidence that the color comes from the water or the mirror?

What was learned: What is white light? What is color? Why do objects have color?

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

Light is a form of energy given off by the —1—. The colors of the spectrum combined produce —2— light. The common electric lamp gives off light when its filament is —3—. Modern lamps consisting of mineral-coated tubes filled with gas are —4— lamps. Light reflected so that it may harm the eyes is —5—. A red object reflects only —6— light. Ceilings should be —7— in color to reflect light. Window shades in daytime and not in direct sunshine should be raised to —8—. You should write in such a position that no —9— fall on your work.

A review of the chapter

You have learned that every change that occurs anywhere is the result of some kind of energy change. We use heat, light, electricity, sound, and mechanical energy in everyday living in many ways. Matter, the stuff of which everything is made, is composed of molecules and atoms. The atoms in turn are composed of various kinds of particles of energy. Thus everything is energy, and there may be nothing but energy in the entire universe.

We need to understand many uses of energy. There are good and poor ways of lighting our houses, of preventing things from rusting, of preserving foods, of carrying heat from place to place, and of using various kinds of materials. These problems may all be studied by the scientific method, because we can experiment to find answers. Most of the work of scientists deals with the study of energy changes.

Although we might use devices which apply energy without studying science, we get better results if we understand them.

Word list for study

Be sure that you can pronounce, spell, define, and use in a sentence every word in this list. Each of these words has been defined or explained and used in this chapter.

force	power	energy
mechanical	molecules	atoms
heat	infrared	radiant
dynamo	oxidation	decay
spontaneous combustion	oxide	convection
conduct	electromagnet	repel
insulate	resistance	field magnet
circuit	nichrome	rotor
vibrate	membrane	spectrum
fluorescent	foot-candle	glare

An exercise in thinking

Below are two groups of sentences. The first group contains principles, which are large general ideas. Each sentence in the second group contains an idea related in some way to one of the principles in the first group. Write the numbers from 1 to 30 on a piece of paper or in your notebook. Find the principle which best explains the idea in the second list. Then after the number on your paper write the letter before the related principle.

Example: *Fire is a result of energy changes.*

The correct letter for the example sentence is **A.**

List of principles

A. Every change that takes place in matter is accompanied by a change in the amount of energy present.

B. Radiant energy travels through space.

C. All matter is composed of molecules, which in turn are made up of atoms.

D. Sound is produced by vibrating bodies and travels in waves through air and other matter.

E. When a conductor cuts a magnetic field a current may be produced.

F. Every conductor carrying a current is surrounded by a magnetic field.

G. When an electric current overcomes resistance heat is produced.

List of related ideas

1. Electricity used to overcome resistance in lamp cords is wasted.
2. Light travels to the earth from the sun.
3. A piece of steel may be magnetized by pounding on it while it is in a coil carrying a current.
4. Each particle of iron ore contains iron combined with oxygen.

5. Moving a magnet past a wire would produce a small current.
6. Fires give off heat and light which are released by oxidation of fuel.
7. Air passing between the vocal cords sets them in motion.
8. Electric motors have two sets of coils which carry current.
9. Space is not warmed by sunshine passing through it.
10. The loudness of sound decreases as distance from its source increases.
11. Heat is the vibration of individual particles of matter.
12. When oxygen combines with iron, heat is given off.
13. The tone A is 440 vibrations per second.
14. Every wire carrying a current produces at least a little heat.
15. Heat travels from a hot stove in all directions.
16. As chemicals in a cell are used, electricity is produced.
17. A compass needle may swing if brought near a wire carrying current.
18. When iron is exposed to warm, moist air it rusts.
19. We use a fairly high resistance wire in toasters.
20. Infrared radiation travels 186,000 miles per second.
21. The wire in an electric lamp produces light because it is very hot.
22. Work is required to throw a baseball.
23. We see by light reflected from objects.
24. A dynamo is made up of coils rotating between magnets.
25. Air pressure comes from the bumping of molecules against each other.
26. A diver can hear noise produced by tapping under water.
27. An electromagnet must have current to keep its strength.
28. Heat is required to obtain iron from ore.
29. A watch may stop if magnetized by being brought near a strong current.
30. Objects which absorb light become warmer.

Some things to explain

1. Why can you whistle?
2. What is the difference between slow oxidation and burning?
3. Why is a cold room poorly heated when it has only a door opening into a warm room?
4. Name five metals which do not ordinarily rust.
5. Explain the difference between an electric battery and a cell.
6. Why is it impossible for an owl to see in the dark?

Some good books to read

Beeler, N. F. and Branley, F. M., *Experiments with Electricity*

Bragg, W. H., *Universe of Light*

Gail, O. W., *Romping Through Physics*

Geralton, J., *Story of Sound*

Hayes, Elizabeth, *What Makes Up the World?*

Meister, M., *Air and Water*

Morgan, A. P., *Getting Acquainted with Electricity*

Shippen, K. B., *Bright Design*

CHAPTER

2

Work in Everyday Living

Do you like to work? Do you like to throw a football, to skate, or to climb fences? As the word work is used in science, work is the process of causing something to move, whether it is for fun or to get something done that is unpleasant.

Anything that helps you to apply force for the purpose of moving something, whether it be a spoonful of soup or a ton of coal, is a machine. We are so accustomed to thinking of machines as being big and impressive that we are likely to forget the little, everyday machines that make life much easier for us.

By use of machines we cannot save work, but we can make it easier for ourselves. It takes the same amount of work to run upstairs that is required to climb a ladder to the same height, but we do not make ourselves so tired by use of the stairs. We say that the stairs are easier to use, because the climb is more gradual. That is exactly what a scientist would say, too, but he would express it more accurately.

Although it is impossible to do work without using energy, it is not necessary for us to use our own energy to do it. We can use many other forms of energy instead. It is easier to push the button and let the electric current turn the washing machine than it is to put a crank on it and turn it by hand. It is easier to step into the elevator than it is to climb stairs.

We are so accustomed to using machines that we could hardly live without them. Our food, water, transportation, and clothing are made available to us only because we have machines to use. In fact, the age in which we live is called a machine civilization. Can you think of a better name for it?

Some experiments to do

1. Obtain a funnel and a table tennis or ping-pong ball. Put the ball in the funnel, and blow through the

International Nickel Company

Both the road and the bus are machines. The sloping road is a simple machine; the bus is a very complex machine.

stem. Blow as hard as you can. Hold the funnel mouth down while blowing. Do you see evidence that the pressure in a moving stream of air is less than normal pressure? Can you apply this idea to an airplane wing?

2. Obtain a spool, a stiff card, and a pin. Thrust the pin through the card so that the pin projects straight up when the card is on the table. Place the hole of the spool over the pin. Pick up the spool and card in this position, and blow through the hole in the spool. Can you blow the card from the spool? How does this illustrate one principle of the airplane wing?

3. Bring an atomizer to class and demonstrate how it works.

4. Obtain two small balloons, a piece of glass tubing, and some rubber bands. Blow up one balloon quite fully, and the other about half full. Close them with rubber bands. Connect the balloons by attaching each to one end of the glass tube. Loosen the bands so that the balloons can pass air from one to the other. Which one blows up the other? Repeat with other balloons and balloons of different size.

5. Obtain a watch or a ticking clock and a balloon. Inflate the balloon and hold it between your ear and the watch. Move it back and forth. Does it seem to shut off the sound or to magnify it? Explain.

6. Use a roller skate, a brick, a

Borg-Warner Corporation

Most heavy lifting today is done by machines. This fork lift is used to pile lumber.

string, and a spring balance to demonstrate that rolling friction is less than sliding friction.

7. Rub a penny briskly on your clothing to see if you can make it warm.

8. Bring several simple tools to school to show that they are combinations of levers or inclined planes.

9. Bring an inner tube and bicycle pump to class. Demonstrate the operation of this compressed-air device. Can you measure the amount of air in the tire?

10. Look up pictures of pile drivers in reference books, and make a model pile driver.

11. Make a model windmill. Use strips of metal cut from a can for blades, and a spool for a hub. Mount the spool on a nail. Cut slits in the spool, and force the blades into them or tack a circle of metal on the end of the spool; make blades by slitting it. Twist the blades to make vanes.

12. Make a model water wheel. There are many materials you can use, and several ways of making the wheel. Plan a method for yourself.

13. Make a model compressed-air water tank. Use a large test tube, a two-hole stopper, and glass tubing. Why can you not force the water into the tube halfway?

14. Obtain a sink pump or plumber's friend. Wet it and push it against a smooth surface. Try to release it by pulling straight out on the handle. Next twist it and admit air beneath it. Explain how air exerts pressure.

Some subjects for reports

1. How a sailboat operates and how it sails against the wind
2. How compressed-air coin carriers work
3. How a doorcheck works
4. Pressure and vacuum in a coffee-maker
5. Famous wind tunnels and their uses
6. The effect of inventing machines upon our way of living
7. The effect of machines on jobs
8. The number of machines in a modern house

1. Can we do work?

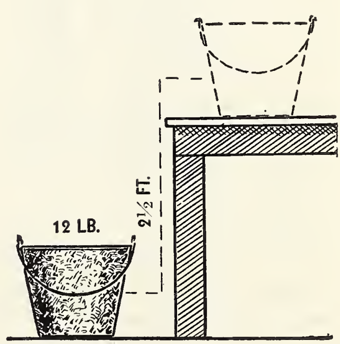
Doing work is defined as causing something to move. Things do not move easily. There is always something that holds them back—a resistance to motion. What this resistance is depends upon the situation. If it is opening a drawer that is stuck, it is one kind of resistance. If it is lifting a box of canned corn, it is another. And if it is pushing an automobile on a level road, it is still a third kind of resistance.

How does gravity offer resistance to doing work? Everything on the earth is pulled down toward the earth's center by the force of gravity. If you want to lift any object, you must pull up with more force than the downward pull of gravity. Lifting anything is really a tug of war with an invisible opponent.

The energy you apply to move an object is called a force. A force is a push or a pull.

If you do not push or pull on an object with enough energy to cause it to move, you are not doing work. You might stand and lift at the corner of the school building all day, and at night be completely tired out. But, unless something very unusual happened, your efforts would go to waste without having accomplished any work. Yet if you blink your eye, you have done work; for even so slight a movement as that of an eyelid is use of energy to move something.

The scientist says that work is done when force overcomes a resistance. The way to measure work is to find the amount of

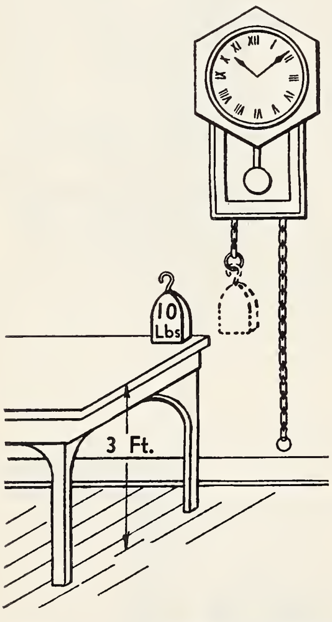


Explain how 30 foot-pounds of work is done when the pail is lifted to the table.

force used, and to find how far the object was moved by the force.

Suppose you start with a pail of water on the floor. The pail of water weighs 12 pounds, and the table is $2\frac{1}{2}$ feet high. You want the pail on the table, so you lift it. How much work have you done? Twelve times $2\frac{1}{2}$ equals 30. But 30 what? The distance is in feet, the weight in pounds. The name of the unit of doing work, then, is the foot-pound.

Suppose that you have a faucet on the bottom of the pail, and a toy water wheel which you are using to operate a mechanical toy. You run a hose from the pail to the water wheel, and the water turns the wheel. The energy which you stored in the water by lifting it is released when the water runs downhill and turns the water wheel.



The weight on the table contains stored energy. This energy may be released to do useful work by hanging the weight on the chain of the old-fashioned clock. How much work can be done?

There is a big machine called a pile driver which works on the same principle. It is made of posts and pulleys and other parts. An engine pulls a weight up to the top of the posts. Then it is released and it crashes down on the top of a post which drives into the ground. This machine is used to drive the posts you may have seen around the ends of docks. The machine does work in using energy to lift the weight. Then the same energy is used to drive the post. Of course there is some loss of energy because the parts of the machine rub against each other.

How much is a pound? A pound is the amount of pull which gravity exerts upon a standard measure. This measure is a piece of metal kept in the Bureau of Standards in Washington, D. C. It is carefully protected to keep it from gaining weight by rusting or by dirt sticking to it or from losing weight by being worn away or scratched. Any other piece of metal with the same amount of matter in it as this standard weight is a pound.

The easier way to measure a pound is to use an ordinary spring balance. Gravity acting on a weight can be used to stretch

the spring. All weights which are equal will pull the spring down equally far. And if we do not have too strong a spring or too heavy weights, two equal weights will pull the spring down twice as far as one of them will. It is thus easy to make a spring balance that will weigh objects. We need only put a pointer on the spring, and note by marking on a scale where the pointer is when one, two, three, or more pounds are added. The one thing we must be careful about is to avoid stretching the spring so much that it will not go back to its first position when we take the weights off.

How can we measure work? It is easy to measure the amount of work done in lifting an object. You multiply the weight times the distance you lift it. If you want to measure a push or pull sideways, knowing the weight of the object moved is not enough. If you use the spring balance to pull with, you do the work and measure the force at the same time. You can pull a wagon along the sidewalk with a spring balance, noting the pull. Then of course you must measure the distance too. Then you can multiply the force by the distance to get the answer.

When you pull a wagon along the sidewalk, you overcome friction, and you also overcome the natural tendency of any object to stand still. If you note the pull on the balance carefully, you will see that the first pull required to start the wagon is greater than that required to keep it moving. When you stop pulling, the wagon does not stop immediately, but has a tendency to keep moving. If you want to stop it suddenly, you must use force. Things resist being started or stopped.

Of what use is work? When we want anything moved we must do work. Cooking your dinner or going to bed is work.

In factories there is much work to do. After a locomotive has been made, it is necessary to move it to a track. The locomotive is picked up by a system of pulleys operated by a big engine and carried along a track near the ceiling, until it is put down on a regular railroad track to run under its own power.

To move a hill aside to make a road requires a tremendous amount of work. You probably have watched power shovels, trucks, and tractors knocking the hill down and hauling it away. In lumber camps logs must be hauled long distances through the woods, put on trains, and taken to the mill. In the mill there are many saws and other machines which cut the logs into boards. Cutting is another kind of work.

On the farm there is a system of pulleys used to lift hay into the barn. A horse does the work by walking along the ground. The pulleys serve as machines to apply the force.

There are so many other uses of work that you can make your own list of hundreds of examples.

DEMONSTRATION: HOW CAN WE MEASURE THE FORCE OF GRAVITY?

What to use: Coil spring or strong rubber band, weights, ring stand, ruler.

What to do: Hang the spring on the ring stand. From it hang enough weights so that it will almost stretch. Then add more weights, measuring the amount of stretch with the ruler. Repeat the experiment to test your accuracy. If the results of the two trials do not agree, do the experiment a third time.

What was observed: What two forces act upon the weights? Which force pulls upward? Which pulls downward? Is the force of gravity in proportion to the amount of matter in the weights?

What was learned: How can we measure the force of gravity? Explain.

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

One of the forces which must be overcome in doing work is the force of —1—. When work is done, something must be —2— through a —3—. When an 80-lb. boy "chins" himself by lifting his weight 1½ feet, he does 120 —4— of —5—. —6— which is used to do work comes from the sun. The marks on a spring balance represent the pull of —7— on the spring. The standard measure for comparing weights is kept in —8—. A —9— often can do more work than a man can. Work cannot be saved but —10— work can be avoided.

2. What forces resist motion?

All of the energy which we expend is not used to lift things. When we push a box along the floor, most of our energy is used to overcome the resistance caused by the box rubbing against the floor. When an engine pushes an automobile along the road, only part of its energy moves the car. A part of it is used up as the moving parts of the car rub together.

What is friction? Whenever two surfaces rub together, there is a resistance to motion. This resistance is called *friction*. Friction makes it possible for us to walk across a floor. Walking on ice is difficult because there is little friction, and walking with roller skates is still more difficult. There is no movement in the world that does not depend in some way upon friction.

Some friction is desirable; friction makes it possible to sharpen an ax on a grindstone. When the ax is held against the stone, the friction of the stone cuts and scratches the steel until part of the material is worn away. Usually friction is undesirable. Dragging a trunk across a level floor to get it to another place is waste work, for nearly all of the energy is used to overcome friction.

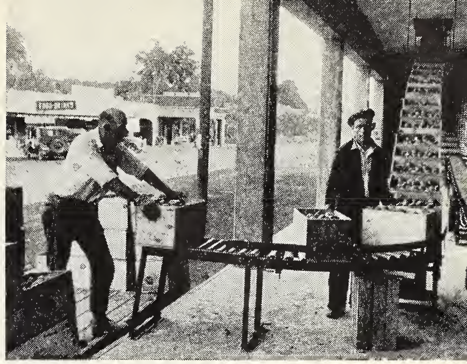
What becomes of energy used in overcoming friction? If you drive a nail into a board and quickly pull it out, it feels hot to the touch. The wood does not

feel hot because it is a poor conductor, while the nail gives off heat readily. Driving the nail into hard wood makes it hotter than does driving it into soft wood, because more energy is required to overcome the greater friction of the hard wood against the nail.

When an automobile moves, energy is lost as the parts of the machine rub against each other. Although each part seems perfectly smooth, it really is not, and friction results. The energy used in overcoming friction is lost in the form of heat, but since the heat is distributed in many parts, no one part becomes particularly warm. The friction of the wheels against the road produces heat generally not noticed. However, the temperature of the tires may be raised as much as 70 degrees F. by fast driving.

Work used to overcome friction always produces heat. The same amount of work always gives the same amount of heat. Work used in overcoming friction cannot be used over again as can work done in lifting objects. The heat produced is lost into the air, never to be recovered.

How much work is used in overcoming friction? If you use a spring balance to pull a box with a smooth bottom across different surfaces, you can learn a number of things about friction. The forces required will be found to be much different for pulling the box across various rough and polished surfaces.



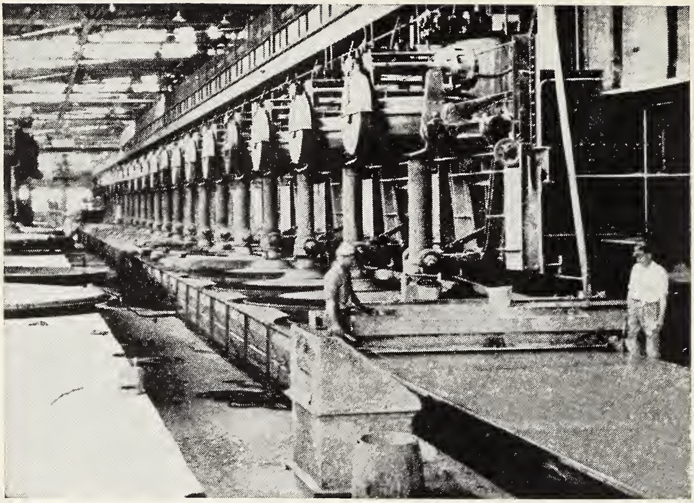
Asahel Curtis

Apples unloaded from the truck are pushed on rollers to the inclined elevator. Beneath the boxes on the incline is a belt operated by a motor which lifts the boxes to the second floor.

From this experiment you can discover that the amount of friction varies with the kind of surface.

If you change the load in the box by adding weights, you discover that the friction increases. Thus you learn that the amount of friction depends upon the pressure as well as upon the kind of surface. If you place the box on some rollers and measure the force needed to move it, you find that the force needed is still different. Rolling friction cannot be compared directly with the sliding friction because it makes the work much easier. Rolling friction varies with the load and with the amount of surface on which the rollers turn.

How can we increase the amount of useful work? From our experiment with the boxes, we find that we can reduce friction by using smooth surfaces. Streamlined trains are made of polished metal, and airplanes are



Pittsburgh Plate Glass Company

These machines apply friction to make plate glass shiny. The first grinders use sand, the next fine sand, the next emery, and the last rouge on felt to smooth the glass.

welded so that no rivet heads stick out to increase friction in the air. Axles and wheels are made of highly polished metal.

Because energy is costly, it is important to prevent its loss by friction as much as possible. One of the commonest ways to reduce friction is by the use of oil. Oil forms a thin film which coats the moving surfaces and makes them smoother. Oil is used on the sewing machine, the washing machine, the electric fan motor, and squeaking door hinges to reduce friction. In the automobile, oil is applied wherever two parts rub against each other. If there is too little oil, the parts of the machine may soon become hot and stick. The metal which is rubbed together may even be melted by the heat produced.

Modern transportation depends upon the use of wheels to overcome loss of energy by using rolling friction. The ordinary wheel is built around a hub [center part] which turns upon an axle. The friction between the inside of the hub and axle is a sliding friction. This may be changed to rolling friction by the use of balls or steel rollers. A groove is cut into the inside of the hub and the outside of the axle, and the steel balls are inserted to carry the load. These are called ball bearings. Adding oil to the ball bearings protects them from wear and makes them run still more smoothly.

Roller bearings consist of a row of round rods placed around the axle to roll as the hub turns. These have the advantage over

the ball bearings of standing up under much heavier loads. Balls tend to flatten when subjected to too much weight. Passenger trains now use roller bearings to provide smoother riding and greater economy.

Smoothing roughened surfaces also helps to reduce friction. Desk and table drawers which stick and squeak may be made to slide more easily by applying soap to the places where the friction is greatest. If the drawer is too tight, the friction may be caused from pressure. In this case, it is better to plane off a thin shaving of wood to reduce the friction.

A ring may be removed from a finger easily and without pain by soaping the finger thoroughly. The soap makes the surface slippery and permits the ring to slide off easily.

The joints of the bones and all parts of the body which slide upon each other are made smooth by a slippery liquid which reduces friction.

Does matter resist being moved? We know now that gravity is a force which must be overcome before we can lift anything. And friction must be overcome when things rub together. But matter itself has a kind of built-in resistance to motion. If you hang a heavy weight from a cord and strike it sharply with a light hammer, the weight may not move much. But if you give a slow, steady push against the weight it will move. Similarly it is much more difficult to start an automobile rapidly than to start it gradually.

General Electric Company

The electric motor turns the grinding wheel, which applies friction to sharpen the ax.

When an object is already moving it resists being stopped or turned aside from a straight line. You may have fallen down when you tried to turn a corner rapidly. Boys learning to catch a pitched baseball learn to let the hands "give" with the ball instead of stopping it by holding the hands stiff. At the end of a race you must slow down gradually. The resistance of an object to being moved when it is at rest, or of being stopped when it is in motion, is called inertia.

DEMONSTRATION: WHAT FORCES RESIST MOTION?

What to use: Brick, board, round pencils, soap, spring balance, light string.

What to do: Tie the string to the brick so that it can be dragged along the board by pulling it with the spring balance. (1) Note the amount of force needed to pull the brick along the board. (2) Put pencils under the brick to serve as rollers, and pull the brick

along. Note the force required. (3) Wet the board, and soap it until it is slippery. Again drag the brick on the board, noting the force needed. (4) Put the brick on the floor, and jerk the string violently. (5) Weigh the brick.

What was observed: Record the results of the experiment.

What was learned: What are two methods of reducing friction? Does an object at rest tend to remain at rest? Explain.

Things to think about

Match the following subjects and predicates. Copy the sentences in your notebook.

Subjects

1. Friction
2. The energy lost by friction
3. Loss of energy by friction
4. Use of oil on surfaces
5. Steel knives
6. Two kinds of friction
7. Steel balls
8. Increasing the pressure
9. Useful friction

Predicates

A. reduces friction.
B. reduce friction in bicycle wheels.
C. is changed to heat.
D. is applied in automobile brakes.
E. reduces the amount of work done.
F. will increase the work lost by friction.
G. results when two surfaces rub together.
H. are rolling and sliding friction.
I. may be cut by friction.

3. Do levers help us to do work?

Without realizing it fully, we are using levers all the time. Knives, forks, spoons, pencils, brooms, shovels, wheelbarrows, and hammers are levers. In addition to their uses in simple tools, levers make up many of the parts of more complex machines, such as the automobile, the washing machine, and the egg beater.

What is a lever? The simplest kind of lever is a stick or bar used to pry or lift some object in order to move it. A *force* is applied to the lever at some point along its length. The object being moved offers *resistance* at some other point on the lever. The lever rests upon a support or turns around a point, called the *fulcrum.*

Perhaps the simplest form of lever is a teeter board. One child provides the force and the other the resistance. The board rests upon a support placed between the children. As you know, a small child can balance a large child on a teeter. The smaller child must sit farther from the fulcrum than does the heavier child.

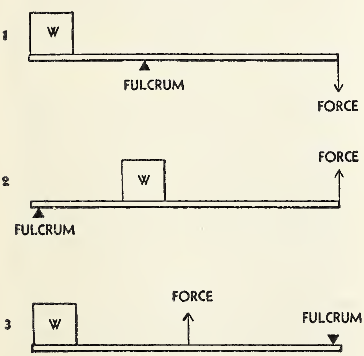
The fulcrum need not always be between the force and the resistance. One end of a pry pole rests upon the ground, which serves as a fulcrum. The force is applied by a man lifting upon

the opposite end. The resistance, which is usually a heavy stone or timber or pipe, rests upon the lever between the fulcrum and the force.

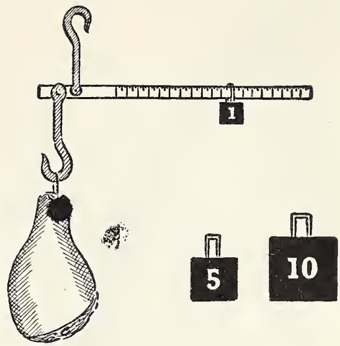
Sometimes the fulcrum is at the end, but the force is applied in the middle of the lever instead of at the end. This is the situation when we use a spade for digging. The hand on the end serves as a fulcrum, while the other hand on the handle provides the force. The resistance is on the blade of the spade.

You can understand better the positions of the force, resistance, and fulcrum by studying the diagram. The first lever is similar to the teeter board, the second to the pry pole or wheelbarrow, and the third to the shovel, broom, or fishpole.

More than half of all machines are levers. Many other machines which seem much different from



There are three ways that the force, the fulcrum, and the weight or resistance may be arranged. Because of this we say that there are three classes of levers.

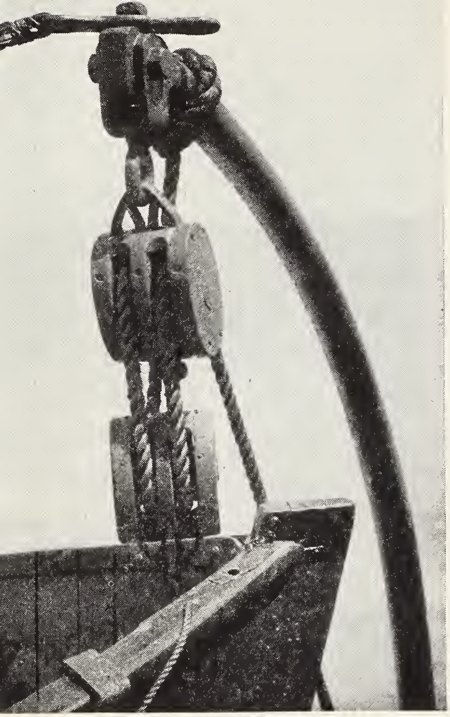


The steelyard balance has unequal arms. If the distance between the hooks is one-ninth as great as the distance from the middle hook to the weight, what does the ham weigh?

levers on first thought are really more complex arrangements of one or more of the forms of the simple lever.

Is a wheel and axle a lever? A special type of lever is called the wheel and axle. If you have a spool on which a thread is wound, you can wind on more thread by turning the rim of the spool. If a weight is hung from the thread, you can lift it up by winding up the thread. The center of the spool is the fulcrum. The force is applied at the rim of the spool. The point from which the thread is suspended is the resistance.

The automobile steering wheel is also an example of a wheel and axle. The force is applied at the rim of the wheel. The rod which supports the steering wheel offers the resistance. The axle of the steering wheel is attached to other simple



The lifeboat is suspended by ropes running through pulleys. One pound pulling on the rope will lift four pounds on the lifeboat.

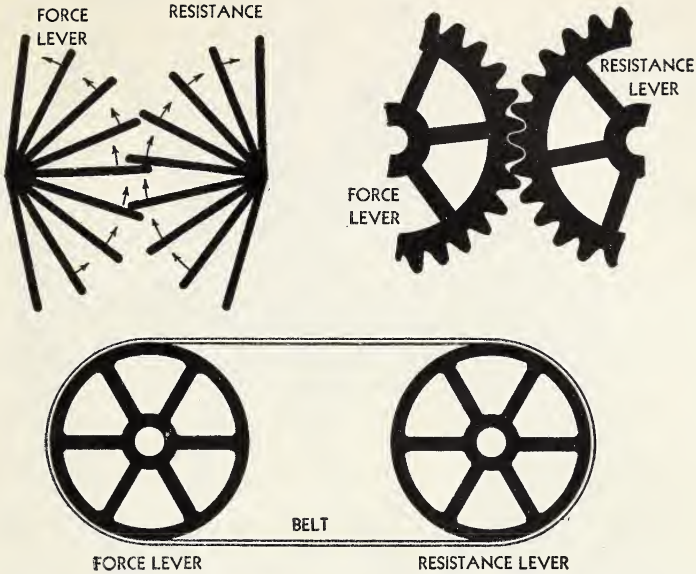
machines to turn the wheels of the automobile.

In digging wells men often use a wheel and axle to lift soil and rocks from the hole. The "wheel" has only one spoke, the stick to which the handle is attached. A tool grinder which is turned by a crank is another type of wheel and axle. The food grinder and egg beater also use the wheel-and-axle type of lever. All belong to the second class of levers. Can you explain why?

How do pulleys work? If a pulley is used to support a rope to raise an object attached to one end of the rope, it is a lever of the seesaw type. The axle of the pulley is the fulcrum. The resistance hangs from a rope on one side of the pulley, while the force is applied to the rope hanging from the other side. Since the spokes of a wheel are of equal length, the only advantage gained by the use of one fixed pulley is to change the direction from which the force is applied.

The pulley may be supported on the rope so that it can move up and down, and one end of the rope is attached to a support. Then the weight is hung on the pulley, and not on the end of the rope. In this way two ropes are made to support the weight, each one holding up half the weight. A person pulling on one rope need apply a force equal to only half the weight to raise it. But in doing so, however, he must pull two feet of rope through the pulley for each foot the object is lifted. While he gains in force, he loses distance.

Pulleys are used more commonly than most people think. Every well-made wooden window frame in which the windows can be raised and lowered contains pulleys. A pair of pulleys is located at the top of the frame for each half of the window. Ropes are run from the window sash over the pulleys to weights inside the frame. If the weights are correct, they will just balance the weight of the window. If the cord supporting the window should break, you will discover how diffi-

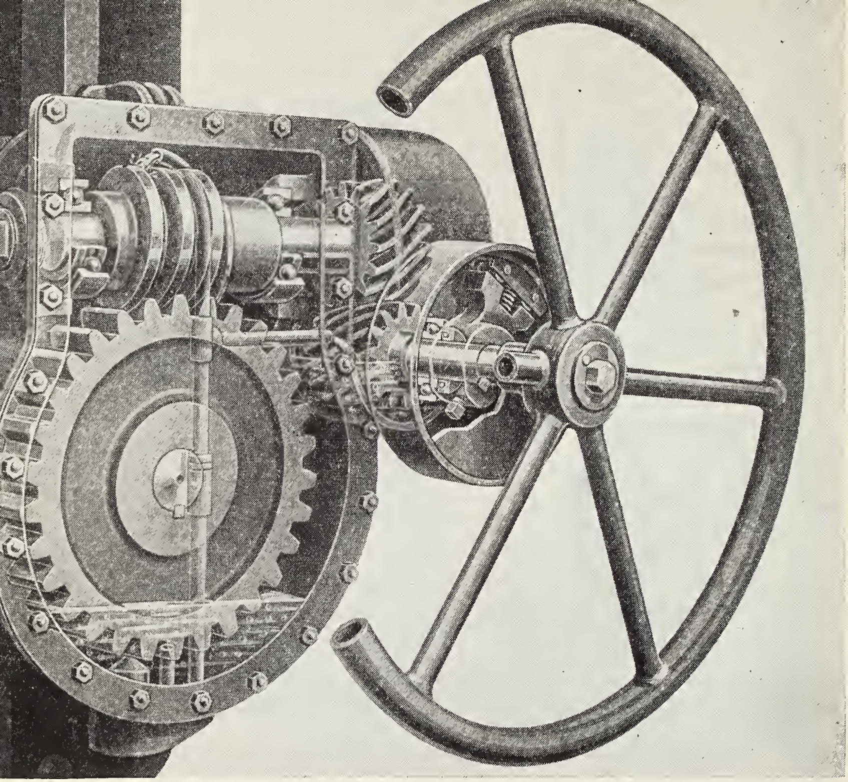


Gears and pulleys are really levers. If you study these diagrams you can see that the levers of one wheel turn the levers of the other wheel.

cult it is to open a window that does not have weights.

Pulleys are also used on boats of all types. Lifeboats are supported by pulleys. To lower the lifeboat, it is only necessary to untie the loose end of the rope. The weight of the boat will cause it to go down. In lifting the boat from the water, it is necessary to pull all of the rope back through the pulleys. If it is 10 feet to the water, 40 feet of rope will be necessary to go through a set of pulleys using four ropes. It will be necessary to apply the needed force through 40 feet to raise the boat 10 feet. However, if the boat weighs 1000 pounds, only 250 pounds of force would be needed, providing there was no friction. Since there is considerable friction, more force than one-fourth of the total weight will have to be used. The advantage which is gained by the use of pulleys can be determined by counting the number of ropes which actually support the weight.

What are gears? Sometimes the rim of a wheel has notches cut in it in such a way that they will fit into similar notches of a second wheel. As power is applied to either the rim or axle of one wheel, it will be carried to the rim of the other wheel. Such wheels are called gears. At first thought, they may seem to be very different from levers. Yet whether the gear wheels have separate spokes or not, the point at



Whiting Corporation

This drawing of gears is made so that you can see inside a machine. These gears are somewhat more complex than usual. Note that the gears are washed with oil to reduce friction.

which the contact [touching; coming together] is made with the second gear is one end of the lever. If the gears turn, the point of contact remains in one place, but different parts of the gear make the contact. By using gear wheels of different sizes, both the speed and the amount of force applied can be controlled. If the second gear is to turn faster than the first, or driving, gear, the second, or driven, gear is made smaller than the first. But if more power is needed, the driven gear is made larger than the driving gear. The smaller gear always turns faster than the larger gear, but the larger gear always has more power.

How are combinations of levers used? Machines contain many wheels, gears, rods, and axles. If you examine some machine, you can discover that nearly every part is some adaptation of the simple lever. Belt wheels, gears and shafts, and wheels and axles are all levers. Where the rotation of a wheel is

to be changed to a back-and-forth motion, a lever is always used to produce the back-and-forth motion. Examine the next machine you see to find how many adaptations of the lever you can recognize.

DEMONSTRATION: HOW DOES A LEVER WORK?

What to use: Ruler, weights, ring stand, spring balance, string.

What to do: Support the ruler at the middle, so that it balances. Hang the spring balance below one end of the stick, and hang a weight at the other end. Hold the balance to keep the stick level, and note the force required. Move the weight toward the center of the stick. Note the readings of the balance each time the weight is moved.

Remove the ruler from the ring stand, and fasten the weight near the middle of the ruler. Put one end of the ruler on the edge of the table and support the other end by lifting it with the balance. Move the weight first toward the balance, and then toward the table edge. Note the changes in the reading of the balance.

What was observed: Which lever is like a teeter board? Which is like a pry pole? When the distance from the turning point [fulcrum] of the lever to the weight is increased, what change takes place in the reading of the balance.

What was learned: What is the relation between the distances on a lever, the amount of weight used, and the force required to support the weight?

Kaiser Company, Inc.

The screw-type drill is being used to make holes in coal. An explosive is placed in the holes and used to loosen the coal for loading.

Things to think about

Copy the following sentences in your notebook. Select the correct ending for each sentence.

1. A wheel and axle is the same type of lever as a (*a*) seesaw (*b*) wheelbarrow (*c*) shovel.
2. We use crowbars because they (*a*) move things rapidly (*b*) permit us to use a small force to move large objects (*c*) are light in weight.
3. A gear is really a kind of (*a*) wheel (*b*) tool (*c*) lever.
4. Pulleys are used with belts to (*a*) carry force from one place to another (*b*) lift boats (*c*) reduce friction.
5. On a seesaw the larger person sits (*a*) nearer the center (*b*) farther from the center (*c*) where he chooses because he is bigger.
6. Windows are balanced with weights by the use of a (*a*) wheel and axle (*b*) pulley (*c*) lever.
7. The point around which a lever turns is the (*a*) end (*b*) center (*c*) fulcrum.
8. In its simplest form the lever is a (*a*) wheel and axle (*b*) straight rod (*c*) pulley.
9. In a single movable pulley the weight is supported by (*a*) the force exerted (*b*) both ropes (*c*) a single rope.

4. How does an inclined plane help to do work?

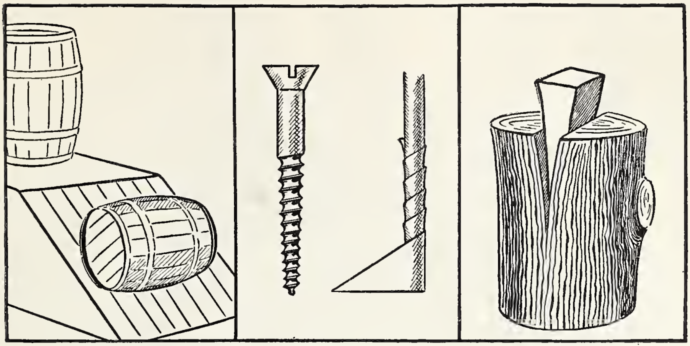
When we walk up a hill or a flight of steps, we are using a sloping surface to raise a weight. Such sloping surfaces are called inclined planes. Of course steps are not planes, but are notches in a plane. When one considers that surfaces are rarely level, this method of raising or lowering weights is one of the most widely used of all devices. A commonly used incline plane is a short plank used to raise heavy objects such as barrels to the floor of a truck.

How are inclined planes used? Where a road passes over a hill, it is necessary to lift a load against the force of gravity to a distance equal to the height of a hill. Since the steepness of the grade which a car can climb is limited, roads are planned to make the slope as gradual as possible.

But regardless of how long the hill may be, the effective work done consists of moving the load through the vertical [up and down] distance to the top of the hill. Sometimes it is necessary to build miles of winding road in order to keep the slope gradual and at the same time get over a hill. Less force is required to overcome gravity on a gentle slope than on a steep one.

It is very important that roads be made of smooth, hard materials. If the road material is soft, wheels sink into it and must be constantly lifted from the hollow places which they make. As the wheel turns, it is constantly rolling up the sloping side of the hollow place. When a load is lifted out of a rut or over a stone, work must be done.

Railroad tracks are built with



There are three forms of the inclined plane. The first is the skid. The second is the screw, which is an inclined plane wrapped around a rod. The third is the wedge.

even more gradual slopes than those used for automobile roads, since the load which the engine must lift is much heavier. If the slope is too steep, the wheels of the engine slip on the rails. In some places where it is desired to transport people and materials through a short distance to the top of a mountain, a steep inclined plane is used to lead directly to the mountaintop. Since it is so steep that the friction of the wheels will not hold the load, cogwheels are provided to pull the locomotive up the hill, and the other wheels are used only to support the weight.

How are wedges used? The most common inclined plane of all is the wedge. The wedge has a narrow edge which can be driven into wood or cracks between objects. The sides of the wedge slope. As the wedge is driven in, its sides push against the objects to force them farther apart. A knife blade is a wedge. If you place the blade with one side flat on the table, you can easily see that the other side slopes upward to make an inclined plane. A wedge is used in cutting stone. As it is driven into a small crack or against the surface, the parts of the stone are pushed aside.

Woodsmen use a wedge to drive into the crack made by the saw in cutting down a large tree. Without the wedge the weight of the tree tends to close the cut and pinch the saw. A carpenter's chisel and a doorstop are common and useful wedges. Some wedges do not have flat surfaces, but are rounded. A needle is a round wedge. As it enters a tiny opening in the cloth, it forces the threads apart. Pushing aside the threads of the cloth is work—a force acting through a distance.

How do screws help us do work? If you examine a screw, you can see that the thread runs around the central rod so that each turn rises above the last. If

Spokane Chamber of Commerce

The skid is used in loading logs on a truck. A chain attached to the truck is passed under the log and over the truck. A team of horses pulls the chain which rolls the log on the truck. Note the levers the men are using.

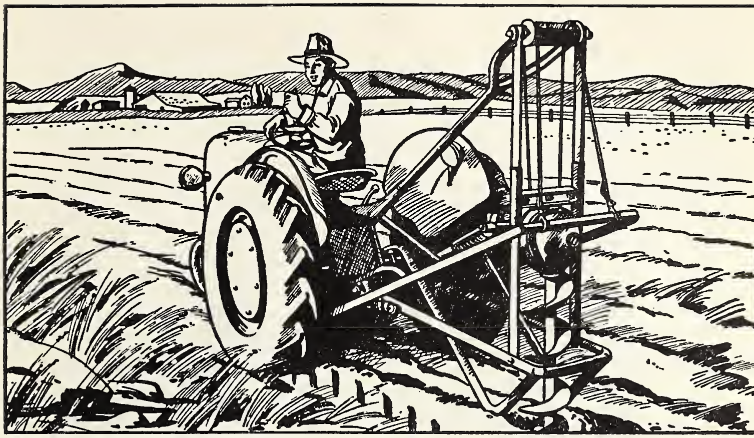
you will cut a triangle out of a piece of paper and wrap it around a pencil beginning with the square end, you will have a slope like the thread of a screw.

As the screw is turned, the edge of the thread cuts into the wood, and the incline serves to pull the screw into the wood. Because the friction between the edge of a screw and the wood is very great, screws are useful in holding pieces of wood together.

The carpenter's bit is another inclined plane. It has a knifelike edge which cuts a shaving, and an incline which lifts the shaving from the hole as the bit turns. The point of the bit is a screw which draws the cutting edge deeper into the wood.

A screw is used in a coal stoker to force the coal through a pipe and into the bottom of the furnace. This screw must be made very strong to move any but small-sized pieces of coal through the pipe.

The common fruit jar and many bottles are made with screw tops to keep the lids tightly in place. Light bulbs screw into



Tide Water Associated Oil Company

Mounted on the rear of a farm tractor is an auger used for boring post holes in the ground. What kind of simple machine is an auger?

sockets to hold the light bulb tightly against the point of contact. Fountain pens have caps screwed on the pens. How many other uses of screws can you list?

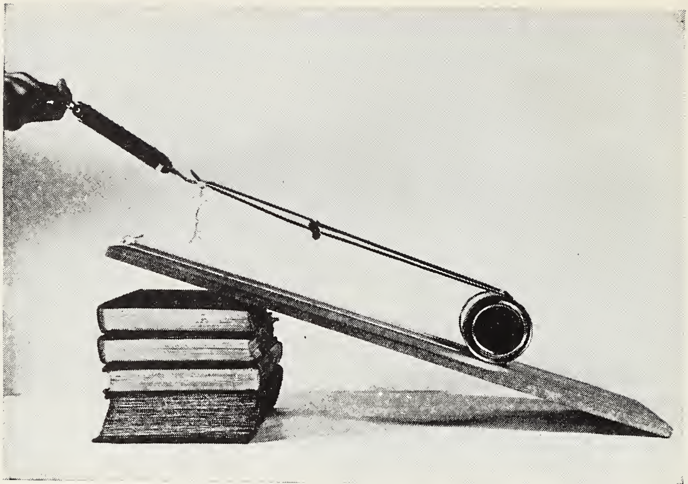
What are simple machines? There are six simple machines: the lever, the inclined plane, the screw, the wedge, the wheel and axle, and the pulley. We have seen that these really are all either levers or inclined planes. The wheel and axle and pulley are really levers. It is difficult to realize that all machines are made up of many arrangements of these two simple machines. For example, a wood saw is a series of wedges arranged along a blade or circle of steel. The round saw is turned by the shaft, which applies the force to the teeth of the saw by use of a lever. The pulleys which apply the power are levers.

So it is with all machines. If you study every part, you can find in it either levers in some form or inclined planes in some form.

DEMONSTRATION: HOW DOES AN INCLINED PLANE WORK?

What to use: Board about three feet long, baking-powder can, weights or sand, tacks, string, spring balance.

What to do: Support one end of the board on books. Attach two strings, twice as long as the board, to the upper end of the board with the tacks. Pull the strings tight along the board to the lower end. On top of the strings, lay the baking-powder can filled with weights or sand and tightly covered. (If the weights shift about, stuff the can with paper.) Bring the loose ends of the string back over the can and attach them to a balance. They may be kept spread apart by tying them



What two simple machines are combined in this demonstration setup? Find the pulley and the inclined plane. What would happen if the can was rolled all the way to the top?

to a pencil. Then pull the strings to roll the can up the board with the spring balance and note the force required.

Raise the end of the board, and again pull the strings to roll the can upward. Note the force required. Again raise the board, and note the force required to roll the weight upward. Remove the can from the board, and weigh it.

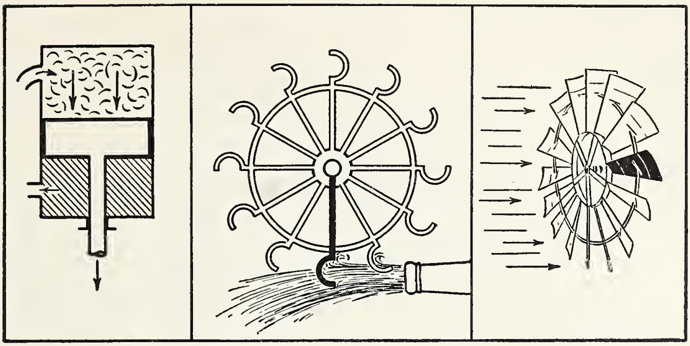
What was observed: Does the force required to roll an object up a skid increase or decrease as the end of the board is lifted? Can you explain how the can and string act as a pulley? Does the weight of the can equal the force required to raise it up the skid?

What was learned: What is the relation between the slope of an inclined plane and the amount of force required to lift an object with it?

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

Two simple machines which are inclined planes are the —1— and the —2—. When an inclined plane is used, a —3— force is required, but the force must act through a —4— distance. All —5— machines are made up of adaptations of —6— simple machines. Winding roads are sometimes built up hills in order to keep the —7— gradual. If a mountain is very steep, —8— are sometimes used to pull a locomotive directly up the slope. Some wedges, such as a needle, have —9— surfaces. The —10— of a screw help to pull it into the wood.



There must be a surface against which force may be exerted—a "handle." The piston and cylinder are used in the gasoline engine, in the steam engine, and in many pumps. The water wheel and windmill are familiar devices for providing a surface against which force acts.

5. How do machines apply energy to do work?

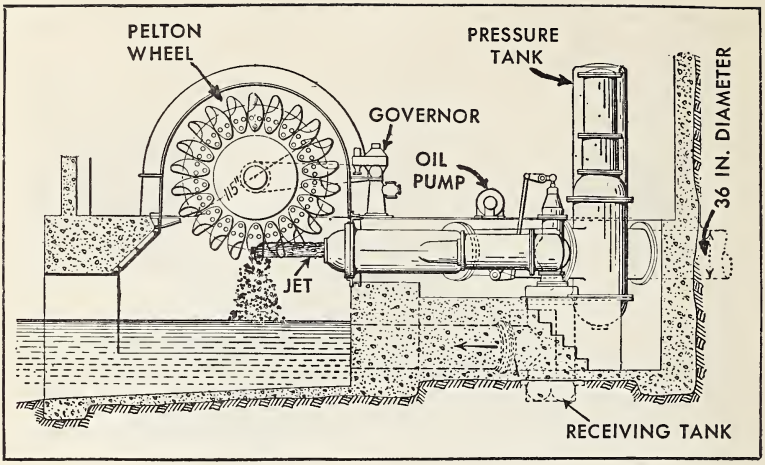
We have been thinking of doing work in terms of using our own muscles to move levers or to pull ropes through pulleys or to roll barrels up inclined planes. Yet we know that most of the work of the world is not done by man's muscles at all. Our muscles are unable to supply much force, compared with the force of the wind or of a mighty waterfall. Nor can we compare our strength with the force of steam in a boiler or of gasoline exploding in an engine.

What is energy? *Energy* is the ability to do work or to bring about changes. We are familiar with many forms of energy. Heat, light, and electricity may be used to produce changes in matter to cause it to move.

The energy of heat stored in gasoline or steam must be applied as a force before it is capable of doing work by operating engines. Heat may also evaporate water and lift it to the mountaintops, from which it flows as a river capable of doing work.

How is energy related to force? You know that force is a push or a pull. If energy is applied to some object on which it can push or pull, force is exerted.

If water is stored behind a dam, it has energy stored in it. Because the dam presents a flat surface against which the water can act, force is exerted on the dam. Yet no work is done by stored water, for neither the water nor the dam is moving. Such stored up energy is called potential [pȯ·tĕn′shăl] energy. Potential energy stored in water really comes from the sun and the force of gravity.



Adapted from Allis-Chalmers drawing

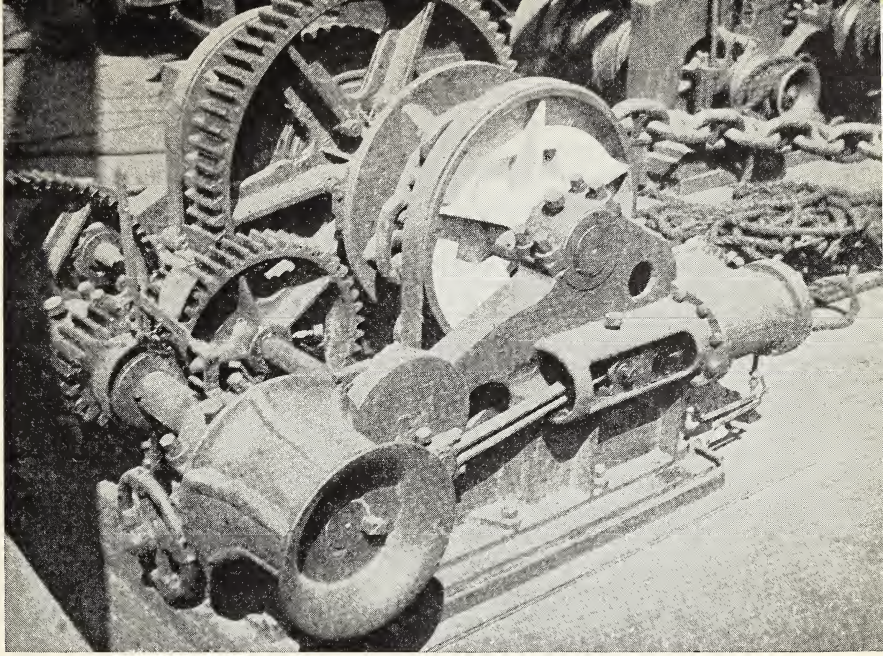
The Pelton wheel, which is widely used for power for electrical generation, requires water under high pressure.

If the water flows over the dam, it still contains the energy but in a different form. The energy of any material in motion is called kinetic [kĭ·nĕt′ĭk] energy. As the moving water strikes various objects in its path, it exerts force upon them.

How is running water used to do work? Before running water can do work, we must provide some surface against which it can push. The simplest practical device for using the force of running water is the water wheel. It consists of a wheel with blades projecting from the rim. The wheel is firmly attached to its axle. When water falls upon the wheel, it strikes the blades or paddles which serve as levers to carry force to the axle. The axle turns and carries the force to a machine. The machine most often turned by a water wheel in olden days was a flour mill in which wheat was ground beneath a slowly turning stone. The pressure of the upper stone and the friction of the upper stone turning against the lower stone combined to reduce the grain to powder.

Today water wheels are still in use, but are generally employed to turn machines which produce electric currents.

The amount of work which can be obtained from running water depends upon the height from which it falls. Since water weighs 62.4 pounds per cubic foot, every cubic foot of water is able to do 62.4 foot-pounds of work for each foot that it falls. Water wheels do not obtain all the kinetic energy from the falling water, for much of the water



The small steam engine is used to hoist loads on a wharf. At the right of the engine is the cylinder, inside which the piston is pushed back and forth by steam. Steam comes from a boiler beneath the wharf. The piston moves a rod attached to the solid wheel.

falls off the ends and sides of the blades before it has given up its energy.

How is wind used to do work? It is impossible to make a practical windmill with the blades set in the same position as those of the water wheel. Instead, the blades, called vanes, are set at an angle. Water flows over the water wheel along the rim, but wind flows through the windmill wheel in a direction parallel to the axle.

Each blade of the windmill is an inclined plane. As the wind pushes these blades sidewise they produce a force which tends to turn the wheel. The turning wheel is attached to a crank, much like the crank to which your bicycle pedals are attached. Attached to the crank there is a rod which leads downward to the pump. As the wheel turns, the rod is moved up and down, and the pump lifts water from the well.

How are expanding gases used to do work? Whenever a gas is under pressure, it tends to expand. If the gas is permitted to expand, it gives off the energy used to compress it—whether the energy be obtained by heating the gas or compressing it with a pump. This energy may be con-

verted into a force which is useful for doing work.

Steam is compressed by the energy put into its molecules when the water is boiled. Steam is confined in a boiler to maintain its pressure. To use the pressure of steam, it is permitted to flow from the boiler into some kind of machine which provides a surface on which it can exert force. The standard steam engine consists of a piston and a cylinder. The piston slides back and forth when steam is admitted to the two ends of the cylinder alternately. When steam is let into one end of the cylinder, the steam behind the piston is permitted to escape. Thus there is always a difference in the pressures of the steam on the two ends of the piston. There are three common arrangements of valves used to permit steam to enter and leave the cylinder, and all are complex in their operation.

When gasoline explodes in a gas engine, gases under pressure are formed. The gas engine also consists of a piston moving in a cylinder. All piston-and-cylinder engines carry force from the piston through a connecting rod to a crank. A piston is really the enlarged end of a lever.

Do electric motors do work? The force of magnetism is just as real as the force of running water or expanding gases. In the electric motor a central part called a rotor is turned by magnetic force. The poles of the rotor are repelled by like poles of the field magnets, and attracted by the unlike poles of the field magnets. Thus both push and pull are used to turn the rotor. This is accomplished by the method of wiring the motor so that the position of the poles of the magnets changes as the rotor turns.

The rotor itself is a wheel and axle, or second-class lever. The iron rods on which the coils are wound are levers which apply force to the central shaft on which the rotor turns. Pulley wheels or tools or machines are attached to the shaft to do work. Look at your electric mixer at home to see how this is accomplished.

DEMONSTRATION: HOW DOES EXPANDING GAS EXERT FORCE?

What to use: Heavy-walled test tube, cork stopper, burner, ring stand and clamp.

What to do: Fill the test tube about half full of water. Put the stopper into the test tube and fasten it on the ring stand. Apply heat and *stand back*. (*Caution: Do not insert the stopper too tightly.*)

The same result can be obtained by putting a piece of dry ice in a heavy pop bottle, and letting it stand a few minutes after the stopper is inserted.

What was observed: How does the tightness of the cork affect the result? Why is there some danger that the test tube may break?

What was learned: Explain how the energy of the flame was changed into a force by the steam, and how work was done.

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

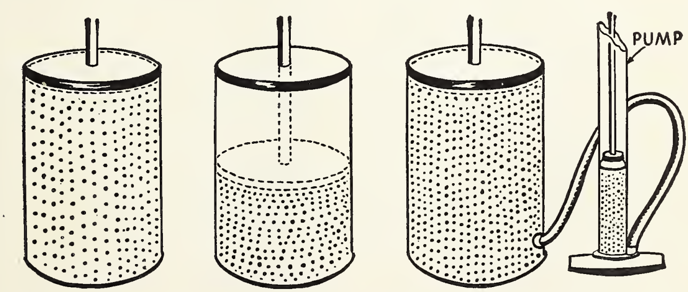
Force is either a —1— or a —2—. Force is exerted upon the —3— of a steam engine, upon the —4— of a windmill, and upon the —5— of a waterwheel. Circular motion is changed to back-and-forth motion by a —6— turned by a windmill wheel. Back-and-forth motion is changed to circular motion in a steam engine by a connecting rod turning a —7— which carries force to the flywheel. —8— energy is stored in water behind a dam, and is changed to —9— energy when the water starts flowing. —10— is that which is capable of producing change or causing movement.

6. How does compressed air do work?

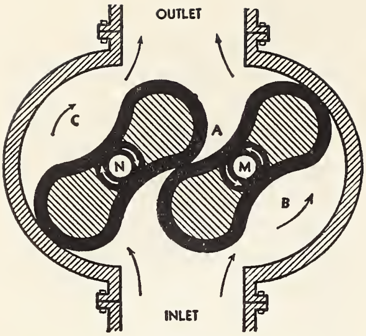
You know that air exerts pressure. At sea level this pressure is 14.7 pounds per square inch on an average day. But we cannot do work with this air pressure because it is the same on all sides of the objects on which it exerts force. We can make air do work only if there is a difference in pressure upon different parts of an object. To obtain a difference in pressure, we can either increase or decrease the amount of air pressure upon an object.

How is air compressed? The pressure of air comes from movement of molecules of which it is made. All molecules of air at a given temperature have the same amount of energy when they strike the surfaces on which they exert pressure. Air pressure comes from the countless molecules of air pounding upon a surface.

In order to increase pressure, or to compress the air, we must cause more molecules to strike against a certain surface in a given time. Thus the problem is to put more molecules of air into a given space.



We can double the pressure of the air in the cylinder either by reducing the volume of the cylinder to one-half its first volume or by pumping into the cylinder twice as much air.



The impellers **M** and **N** fit tightly so that no air can escape at **A.** At **B** air enters the space between the impeller and the casing. As the impellers turn, air is trapped, as shown at **C,** and pushed into the outlet pipe.

Air pressure can be reduced in a container by reducing the number of molecules of air in it.

There are three kinds of air compressors. The common bicycle pump represents one kind. It consists of a piston which moves inside a closed cylinder. Flow of air into the pump and out of it is regulated by valves. Larger pumps of this type are found in service stations and are operated by electric or gasoline motors. They move air rather slowly but may be used to create high pressures.

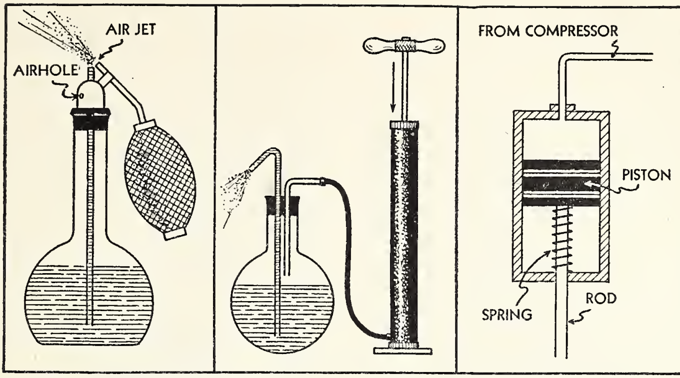
If the common electric fan is enclosed in some kind of cover it may be used to compress air slightly. Compressors of the fan type may move large amounts of air rapidly but generally do not produce much pressure.

A third kind of compressor consists of revolving wheels or impellers [pushers] enclosed in a tight-fitting circular case. These all work on the principle that air is trapped at the inlet by the moving impeller and is pushed through the outlet as the impeller turns. Some of these compressors have impellers consisting of wheels mounted off-center on their axles. The diagram shows another type of rotary-impeller air compressor. These compressors move fairly large amounts of air and will produce fairly high pressures.

Any type of air compressor can be used to reduce pressure, or to create a partial vacuum, by using it to pump or blow air from an enclosed container.

How does compressed air operate machines? Compressed air can be run through pipes or heavy rubber hose from one place to another. For this reason it is useful for carrying power into places where it would be impossible to take large machines. Miners who use air drills in small spaces are able to do work that would be difficult by use of any other type of machine. The air drill is only one of many such machines.

Compressed air machines work more or less the opposite of the way a piston pump works. The machine has an inlet valve through which air goes into a cylinder and pushes the piston. There is a way of closing the inlet valve and opening an outlet valve to let the air out, so that the piston can return to its original position. The piston is often pushed back into place by a spring.



Air is used to do work in many ways. Three common ways are shown here. Atomizers and sprayers use compressed air. The home water system works on the same principle as the wash bottle shown in the middle diagram. The piston and cylinder operate the air brake, the air hammer, the doorcheck, and many other machines.

One of the most important compressed-air machines ever invented is the air brake. It is operated by a tank of compressed air under the streetcar or railroad car. The compressed air runs from the tank through a pipe to the brake cylinder, where it pushes a piston inside the cylinder. A rod from the piston pulls the brakes against the wheels. The brakes are blocks of metal shaped to fit against the rims of the wheels. Friction stops the turning of the wheels. The compressed air of a train-brake system can be turned on by the engineer or conductor. It may also be turned on automatically [ô′tô·măt′ĭk, self-acting] if the cars of the train become uncoupled. If you have ridden in a streetcar, you have heard the motor of the air compressor start.

Can compressed air move water? Another important use of compressed air is to push water from spaces where it is not wanted. It is used by divers. The diver may wear only a helmet over his head. This helmet has a window through which to look, a tube to let in compressed air, and a valve to let out the compressed air. The pressure of the air is kept great enough to prevent the water from entering the space inside the helmet. For going down to greater depths, a suit is attached to the helmet. For still greater depths, air cannot be used to keep out the water because the pressure would be greater than a man could stand. A large hollow steel ball, in which the pressure maintained is about that of the surface air, is used to resist the pressure of the water. Oxygen carried along, compressed in tanks, is released as needed. Underwater life is studied from such balls.

Another interesting compressed-air device is found in one type of a home water system. An airtight tank is used for storage of water. The water is pumped in at the bottom, and as the water enters the tank, the air in the upper part is compressed. By the time the tank is about half full of water, there is enough air pressure to force water to run through pipes from the bottom of the tank to the second story of an ordinary house. As the water runs out, the air expands, and its pressure decreases. Then more water must be pumped into the tank to increase the pressure. (See page 154.)

What materials are moved by compressed air? When wheat is threshed, the grain is separated from the straw by a process of beating the seed from the heads of the plant. The grain is sifted out and the straw is blown through the machine and out through a pipe to the straw stack. A wheel type of blower is used to provide the pressure. In sawmills the sawdust is caught where it falls beneath the saws and is blown through a large pipe into either a huge burner or the part of the mill where chemicals or other products are obtained from it.

Insulation is blown into spaces between the walls of houses by compressed air. The insulation material used for the purpose is either finely divided mineral, such as asbestos or mica, or some type of wood fiber.

How do sprayers work? There are two general types of sprayers. One is used in perfume atomizers [ăt′ŭm·īz′ẽrs] and in nose and throat sprayers. This type has two tubes. One has normal air pressure. The other tube is arranged so that it blows air across the top of the first tube. The pressure in the first tube is lowered by the current of air across its top, and the liquid is pushed up by the air inside the container. When it reaches the top, the cross current of air breaks the liquid into tiny drops forming the spray.

The atomizer principle is used in the hand-operated plant sprayer, fly sprayers, and all others which are used to move small amounts of light liquids.

The other type of sprayer makes a spray like that from the nozzle of a hose. A stream of liquid is broken into drops by being driven through a nozzle under high pressure. Compressed air is pumped into the space above the liquid, which is forced out through the outlet hose. Compressed air is used in operating the kind of insect sprayer into which air is pumped and in sprayers for paint and other heavy liquids. Several types of pumps and sources of compressed air are used for the different devices. Piston pumps are used where high pressure is needed.

How are low air pressures used? The most common use of the partial vacuum is in the vacuum cleaner. It uses a fan to draw air from the room and compresses it in a bag. The air current created at the nozzle picks up dust, which is strained or

sifted out as the air escapes through the bag. Since the air escapes all over the surface of the bag, it is slowed down so that the dust particles drop out. Of course microscopic particles are probably carried through the bag. Instead of the bag, some vacuum cleaners have air filters containing oil to remove the dust particles.

DEMONSTRATION: HOW IS COMPRESSED AIR USED IN SPRAYERS?

What to use: Flask, air pump, two-hole stopper, glass and rubber tubing, hand sprayer or atomizer.

What to do: Put the apparatus together as shown in the diagram on page 87. Push the stopper in tightly. Pump air into the flask slowly, and observe what happens.

Fill an atomizer or sprayer with liquid, and work the pump. Take the apparatus apart and find the tube through which the liquid rises and the one through which air is blown. Find out how the pump works.

What was observed: Does the pressure show any evidence of blowing the stopper from the flask? Does the rate at which the water flows depend upon the rate of pumping? In the atomizer or sprayer is there a hole to permit air to enter the container of the liquid? Is the pump a piston pump? Can you find any valves?

What was learned: Explain what causes sprayers to work.

Things to think about

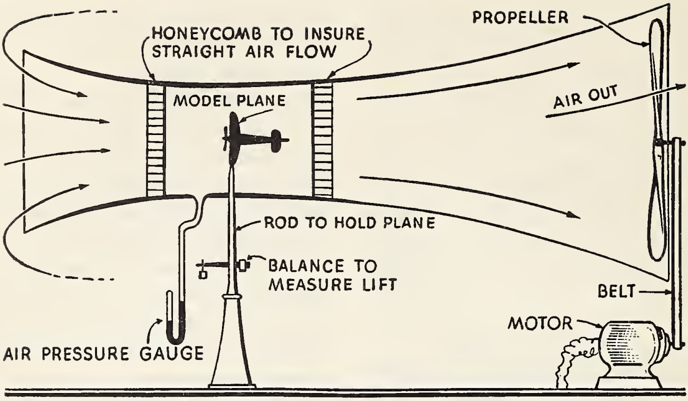
Copy the following paragraph in your notebook. Complete the sentences.

The piston of a machine using compressed air is pushed back into place by a —1— after being moved by the air. Three things which are blown from one place to another by compressed air are —2—, —3—, and —4—. Air brakes, air hammers, and tire pressure-gauges are alike in that they are made up of a —5— moving in a cylinder. Air is —6— in the space above the water in some pressure tanks. The difference between making a vacuum and compressing air is a difference in the —7— of air movement. Moving air is used to keep —8— from freezing. The pressure of air is —9— in the nozzle of a vacuum cleaner and is —10— in the bag.

7. How do airplanes fly?

No other part of our modern civilization illustrates better than does flying the difference between wishing and doing. Men have always wanted to fly, and have dreamed about many ways of doing it. There is the story of the magic carpet which soared through the air without any motor or any support. Ancient tales are full of magic shoes, flying horses, and men who had wings growing from their shoulders. These stories did not recognize any limitations set by laws of machines or by laws of living things.

The first sensible plans for an airplane, based upon study of air



A wind tunnel of small size will serve to test models of planes. The effect of the flowing air on the model is the same as would be produced by the forward motion of the plane.

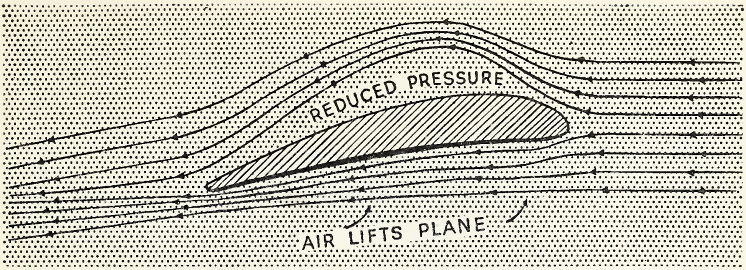
pressure, were drawn by Leonardo da Vinci [dä vēn′chē] in the late fifteenth century. An airplane made from his plans would need few changes in order to fly. However, it had no engine to provide power. Even after Da Vinci drew his plans, it still required about 400 years for man to master the principles of flight and to develop an engine to make flying possible.

How have airplanes been improved? Only 45 years elapsed between the time the Wright brothers flew their first airplane at Kitty Hawk, North Carolina, in 1903, and the flight of an airplane at a speed greater than that of sound.

The first flights proved only that flying was possible. The Wright airplane was made of wood and cloth, with a frame of ordinary iron pipe. It was similar to a big box kite equipped with a motor and skids for running along the ground. It was necessary to improve the motor, to put the plane on wheels, and to reduce the surfaces on which the air resisted the forward motion of the plane. The wings of the first plane were little more than sails set on edge. They were braced with wires and pipes and wood. The wings of airplanes today are made of metal, with all braces inside the wing where they do not encounter any air resistance.

The first airplane to fly across the United States was broken so often in landing, and so many parts were replaced, that it was practically rebuilt several times in the one trip. Jet planes today can fly so fast that they outrun the sound of their motors.

One of the most important means of improving airplanes is through development of laboratories in which experiments with models can be made. The labora-



Above the wing of an airplane is a partial vacuum, which is caused by the flow of air over the rounded front edge of the wing. The lift of an airplane depends in large part upon the difference in air pressure between the upper and lower wing surfaces.

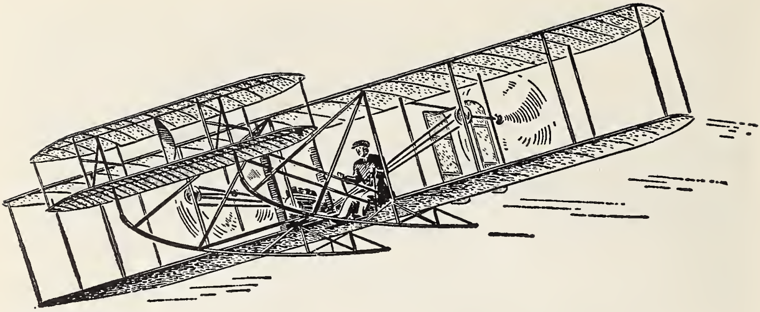
tory consists of balances, measuring instruments, models, and a wind tunnel. The model is put in the wind tunnel, and a strong wind is blown through it. By holding the model in place in the path of the wind, it is possible to measure the forces which act upon it without risking large sums of money and the lives of pilots in experimenting with real planes.

How does an airplane fly? Many boys and girls have made and flown kites. A kite has a flat or curved surface on which the wind exerts pressure. By holding the kite at the right angle in relation to the wind, the lifting effect of the wind is greater than the pull of gravity.

A glider is much like a kite. It looks like an airplane, but has no motor. To get a glider into the air, it is pulled behind an automobile or airplane or pushed over a cliff. The skillful glider pilot can turn his craft into a rising current and be lifted above the ground. He then glides away to another place in search of other rising air currents.

An airplane cannot depend upon air currents to keep it in the air, because currents frequently do not move in the direction one wishes to go. The lifting effect of an airplane is produced by two things: the pull of the propeller and the pressure of air upon the wings of the plane.

The diagram shows how an airplane wing would look if it were cut through crosswise, and how the air flows around the wing when it is in motion. The wing is turned at an angle to the air, and as it moves forward, the air presses upon the lower-wing surface. The air is turned aside by the curved upper surface of the wing in such a way that the air pressure just above the wing is reduced. The normal pressure of the air below the wing tends to push the wing upward to overcome the difference in pressure. Two-thirds of the lift of an airplane wing comes from the difference in pressure, and one-third



Link Aviation, Inc.

This is a drawing of one of the Wright brothers' earliest planes—the one which was flown at Kittyhawk.

comes from the air striking the lower surface of the wing at an angle.

An airplane wing cannot lift the plane unless the plane is moving forward at a fairly good speed. The amount of speed needed depends upon the shape of the wing and the weight of the plane.

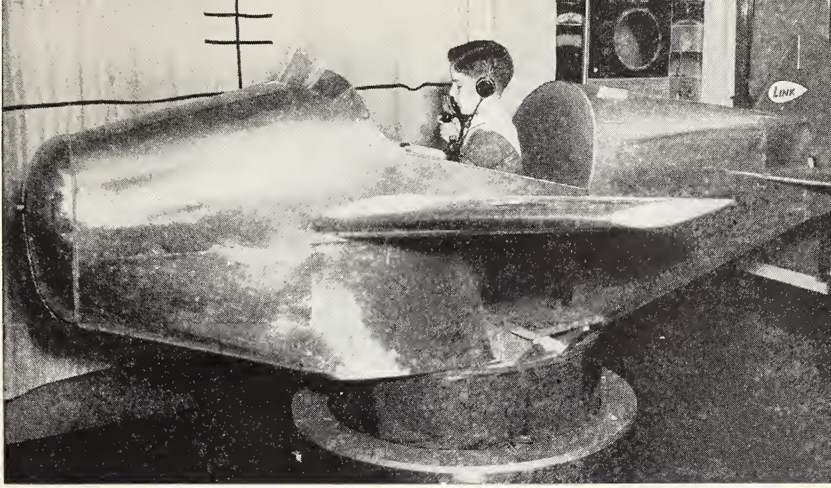
The propeller is made with the same general shape as the wing. The rounded side is ahead, and the pressure of the air on the flat, rear side pushes the propeller forward. The power of the propeller comes from the speed with which it is turned through the air by the engine. A propeller may have two or three blades.

The propeller moves through the air somewhat like a screw that bores into wood. Thus there are two types of force acting on the ship through its propeller: one depending upon difference in pressure and the other upon the movement of the propeller as it is whirled through the air.

How does an airplane take off and land? After the engine is warmed up with the propeller turning slowly, the pilot is ready to fly. He increases the speed of the motor and raises the tail of the plane until the wings meet the air at the angle producing the greatest lift. As the ship moves across the ground, it gains speed until the difference in pressure on the two wing surfaces gives it enough lifting power to fly.

In landing, the operation is just about the reverse. The ship is brought down in a gentle glide with the motor turning slowly. When close enough to the ground, the nose of the ship is raised to increase the angle at which the wings meet the air. This increases the air resistance until the ship loses some of its forward motion and most of its lifting power. At this moment it should touch the ground with all three wheels for a "three-point" landing.

How does the helicopter work?



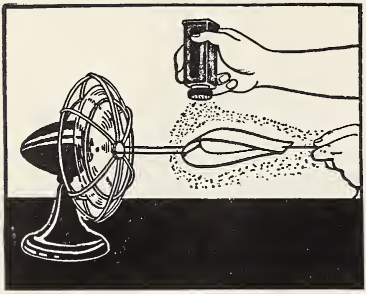
Link Aviation, Inc.

This is a "trainer"—a device fitted with the controls of a small plane. It turns, banks, and responds like a real plane.

The helicopter [hĕl′ĭ·kŏp′tẽr] has no wings or propeller. Instead, it is both supported and moved through the air by two to four wing-shaped, revolving blades called rotors. These blades are controlled so that they are tilted more or less into the air. By controlling the amount of tilt and speed, the pilot may cause the helicopter to rise or fall, and to move in any direction. Helicopters can fly backward and can stand practically still in the air. When the helicopter is in the air the rotors turn even when the engine is turned off. They will thus slow its fall if the engine fails. Helicopters are more difficult to fly than small airplanes.

The helicopter may be used for many kinds of work for which the airplane is not suited. It can be used to inspect land, wires, or any object that may be studied from a few feet above the ground. It is better for dusting crops with chemicals than planes, because it can be flown more slowly and closer to the ground. It can land on small areas, or need not land at all. This ability makes it useful for dropping mail on post-office roofs, for rescuing people in places hard to reach and in taxi service where there are no airfields.

Can boys and girls experiment with airplanes? One of the most entertaining activities of science is making model airplanes. These models are commonly made of balsa wood and cellophane. The motor is a strong rubber band which, when twisted and released, turns the propeller. Such an airplane can be made to fly several hundred feet. Other model airplanes have gasoline engines and fly more than a mile.



This is the demonstration which shows how air flows around an airplane wing.

Model airplanes have been flown more than 100 miles an hour. Many really important ideas regarding the flight of large airplanes have been learned by watching and working with the models made by young airplane designers. Many schools have a model airplane show and contest every year. You may be successful enough to enter your model in a national contest.

DEMONSTRATION: HOW DOES AIR FLOW AROUND AN AIRPLANE WING?

What to use: Electric fan, shaker, flour or other light powder, cardboard, string, working-model airplane, balance.

What to do: Make a cross-section model of a plane wing, as shown in the diagram. Attach strings to the model, and attach it to the fan. When the fan is blowing a steady stream of air around the model, shake flour from the shaker around the wing model. Observe very carefully to note the direction of air currents around the wing model. Air currents can be made steadier by putting a cardboard egg container in front of the fan.

Put the model airplane on a balance, and put enough weights on the other pan to balance it. Turn the nose of the plane toward the fan. Adjust the fan so that the plane is not blown from the balance. Put enough weights on the other pan to balance it again. Does the moving airstream lift the plane?

What was observed: State briefly what you noted in each part of the experiment.

What was learned: Does air flow smoothly around an airplane wing? Does a properly designed wing actually exert a lifting force in a stream of moving air?

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

The —1— brothers flew the first airplane at —2— in the year of —3—. The tests of models and wing designs are often done in —4—. The —5— of air makes it able to exert pressure upon the airplane wings. The —6— of an airplane wing to the air makes the —7— of the air greater below the wing than above. An airplane acquires —8— because of its forward motion. —9— of the lifting power of a wing depends upon reducing the pressure above the wing.

A review of the chapter

Work is done in overcoming the resistances of gravity and friction. The force of gravity gives weight to objects. Work is done when a force acts through a distance. The unit of work is the foot-pound. The amount of work done is obtained by multiplying the distance the object has moved by the force used. Friction consumes a great deal of energy which is changed to heat. Friction may be reduced by decreasing the amount of pressure or by making the surfaces smoother.

Better use of energy is accomplished by use of the two fundamental machines: the lever and the inclined plane. Machines which make it possible to use energy are special types of levers, pistons and cylinders, or magnetic devices. Objects in motion are able to do work as long as they continue moving.

Compressed air has a large number of uses. Three types of compressors are used to produce it. Airplanes of many kinds are used. All depend for their action upon differences in pressure exerted by the air, and upon the inertia of air through which they move.

Airplanes fly because moving air exerts pressure upon surfaces. By curving the upper and lower surfaces of airplane wings in different ways, the pressure on the lower surface can be increased, and that on the upper surface can be reduced. The difference in air pressure is used to lift the plane into the air.

The airplane is moved either by jet engines or by regular engines which turn propellers. Much of the work of developing airplanes is done in wind tunnels. Model planes are used for testing new ideas. Many boys and girls make model planes.

Word list for study

Be sure that you can pronounce, spell, define, and use in a sentence every word in this list. Each of these words has been defined or explained and used in this chapter.

work	gravity	inertia
foot-pound	weight	force
friction	ball bearing	fulcrum
lever	inclined plane	wheel and axle
gear	pulley	wedge
screw	kinetic	potential
piston	cylinder	vane
rotor	compress	vacuum
jet plane	propeller	glider
wind tunnel	helicopter	

An exercise in thinking

Below are two groups of sentences. The first group contains principles, which are large general ideas. Each sentence in the second group contains an idea related in some way to one of the principles in the first group. Write the numbers from 1 to 30 on a piece of paper or in your notebook. Find the principle which best explains the idea in the second list. Then after the number on your paper write the letter before the related principle.

List of principles

A. Work is a force acting through a distance.

B. Energy lost in doing work is changed to heat by friction.

C. Energy may be stored in objects at a height, or in objects in motion.

D. A machine must provide a surface against which a force may be exerted.

E. A machine is a device which applies force to do work.

F. The work done by a machine plus the work lost because of friction are equal to the work put into the machine.

G. Air pressure upon a surface depends upon the number of molecules striking the surface in a given amount of time.

H. When unequal forces act upon an object, the object tends to move in the direction of the greater forces.

List of related ideas

1. We compress air by putting more molecules into a certain amount of space.
2. A nail becomes hot when driven into a board.
3. No work is done unless some object is moved.
4. Wind exerts more force on the front of the windmill vane than does the air on the back.
5. A piston is used in steam and gasoline engines.
6. We always get less work from a machine than we put into it.
7. Skids are used to load logs onto trucks.
8. When the amount of air in a given space is reduced, pressure is decreased.
9. A steam engine uses about 10 per cent of the energy in the fuel, and wastes the rest.
10. We overcome gravity when we lift a pail of water.
11. Water turns a turbine wheel by pushing upon its vanes.
12. The force of air pressure is greater beneath a moving airplane wing than above it.
13. A flywheel turns between strokes because it contains energy.
14. A man can lift a heavy lifeboat by using a block and tackle.
15. A swinging baseball bat may drive a ball a long distance.
16. All real balances are levers.
17. Energy is lost when objects rub together.
18. There is no air pressure in a vacuum.
19. The up-and-down motion of a piston is changed to a circular motion by a crank.
20. Water behind a dam is capable of doing work.
21. A claw hammer is used to pull nails.
22. A sewing machine runs easier if oil is applied.
23. Throwing a ball into the air is work.

24. Using a pulley not only makes it possible to lift a weight, but also warms the hub and axle of the pulley wheel.
25. Energy is lost in dragging a trunk across a floor.
26. Air pressure is normally 14.7 pounds per square inch.
27. When two boys pull upon an object, the stronger one can win.
28. By using pulleys a horse walking on the ground may be made to lift a load into the air.
29. A needle is a wedge which pushes the threads of cloth apart.
30. Every tool has a handle.

Some things to explain

1. Why does the length of a lake behind a dam have no effect on the pressure of the water?
2. Why is a perpetual-motion machine impossible?
3. Why was the invention of the wheel one of mans' most important discoveries?
4. For how many purposes do you use sprayers around your home?
5. Why is it cheaper to send freight by trains than by airplanes?
6. Name several occupations which do not depend upon the use of machines. How certain are you of your choice?

Some good books to read

Britton, K., *What Makes It Tick?*

Carlisle, N. V. and others, *Modern Wonder Book of the Air*

Compton's Pictured Encyclopedia

Dunn, M. L. and Morrisett, L. N., *Power for America*

Dunn, M. L. and Morrisett, L. N., *Machines for America*

Huey, E. G., *What Makes the Wheels Go Round*

Jordanoff, A., *Your Wings*

Meister, M., *Energy and Power*

Morgan, A. P., *Boys Book of Engines, Motors, and Turbines*

Whitman, W. T., *Household Physics*

Spokane Chamber of Commerce

UNIT TWO

COMMUNITY HEALTH

When the pupils saw that Howard had a number of bottles and some flasks on the desk, they knew that they would see an interesting demonstration.

Howard said to them, "One of the most important things that our community does for us is to supply water. I am going to test our city water to see how hard it is. Water is hard when it forms a scum or curd when mixed with soap. I have three kinds of water in these large bottles. The first bottle is partly filled with clean rain water, which contains almost no mineral. The second came from the faucet. The third I made hard by adding some epsom salts and lime. I have a flask of soap solution here. Observe what I do."

Howard poured a small beaker of soap solution into each of the bottles which were about half-full of water. Then he put a cover on each bottle and shook it. The water in the first bottle was soon covered with a heavy suds which filled it almost to the top. The water was clear. The water in the second bottle began to form suds, too, but they were not so abundant, and the water became somewhat milky in appearance. In the third bottle almost no suds appeared, and the water became blue—white. A sticky scum formed on the bottle at the edge of the water line.

Then Howard explained, "You can see that our city water is not completely soft, nor as hard as it might be. Since water is used to wash our dishes, our clothes, and our bodies, I think it is quite important to have a good supply of soft, clean water. You would not like to come from the bathtub covered with a coating of scum like that formed in the third bottle. It would be uncomfortable, and might even cause your skin to become rough or red and sore."

The teacher thanked Howard for the class.

CHAPTER

3

Safeguarding Community Health

Unless you happen to be a hermit, you are in daily contact with a great many other people in your community. You obtain your food from the grocer, your milk from the milkman, your social opportunities from your friends. You swim in a pool or at a beach used by other people. You sit in crowds of people at ball games, the theater, and in school. It is a very good thing for you that most of these people around you are healthy, for their good health protects yours.

While it is very important for you to eat the right food, to exercise and sleep properly, to keep clean, and to be cheerful, you cannot protect your health entirely by your own efforts. Nor can you provide all the necessary conditions for healing yourself if you become ill. You are part of the community in which you live, and your welfare depends upon the welfare of all the other people there.

You may think that most of the great gains in health have come from improved methods of treating the sick. But this is not true. The greatest gain in protecting people's health has been in preventing disease. If you were able to go back three or four hundred years and observe the filthy conditions under which people lived at that time, you would understand why the average person lived less than thirty years. People at that time did not know that many diseases are caused by germs, and therefore could do nothing to protect themselves from diseases.

Today most people do not have to be ill. Those born with a fairly normal body should almost never be sick at all. Sickness is generally evidence of failure of the community or the individual to use best care in safeguarding health.

Some activities to do

1. Practice being "quick on the draw." Obtain a clean handkerchief, and place it in your usual place for carrying a handkerchief. Practice 50

Eli Lilly and Company

This woman is putting bacteria on germ-free gelatin in order to provide germs for study.

times getting it from your pocket or handbag, and getting it in front of your mouth. Do not "shake out" your handkerchief. Use it folded. Why?

2. Arrange with your neighborhood soft-drink place to have a committee inspect methods of cleaning glasses and dishes.

3. Visit a milk pasteurization and bottling plant. Obtain information as to time and temperature used in pasteurizing and in storing milk. Learn how the equipment is cleaned. Note how milk is put into bottles without being exposed to germs.

4. Visit a modern dairy to observe as many ways of keeping the milk clean as you can. Ask what is done to control flies. Learn where wastes are taken to prevent flies from breeding in

them. Learn how milk is cooled, stored, and shipped.

5. Arrange for a visit to a hospital. You will not be taken to parts of the hospital where there are sick people. You may perhaps obtain permission to see how instruments are sterilized, how food is prepared, how rooms are cleaned, and how rooms are arranged for the care of patients.

6. Compare the effects of pasteurization and germicides on preservation of food. Set up nine test tubes, each containing about an inch of water. Into three put a piece of potato, into another three put some raw meat, and into the last three put some milk. Keep one of each set open just as it is prepared for control. Heat one tube of each of the foods by putting them into a beaker of boiling water for fifteen minutes. Seal these tubes with plugs of sterile cotton. Into a third set of tubes put three drops of some common germicide, such as Lysol (*danger*—poison). Observe daily for several days. When you are sure a food sample is spoiling, drop the tube into boiling water and then discard the food. (This should be done only with teacher direction.)

7. Make a survey of the community to find where mosquitoes, flies, and rats might breed. Report to the community health authorities.

8. Visit your community health department. Observe the incubators, the petri dishes, the microscopes, and other tools of the laboratory.

9. In co-operation with your school health service, you might display posters advising every pupil to be inoculated against those diseases that might endanger your health, and which can be prevented by this method.

10. Collect advertising of worthless patent medicines, and display them on the bulletin board with appropriate warnings. Be sure that you know what a patent medicine is, and why it is worthless.

Some subjects for reports

1. The many health services of the typical city
2. The many sanitation activities of your city
3. Protection of health of rural people
4. The 4-H Club health program
5. The decline in contagious disease since 1900
6. Jenner and vaccination
7. Pasteur and the germ theory
8. Methods of insect control used in your community
9. The last epidemic of your community, and its causes
10. The Pure Food, Drug, and Cosmetic Act
11. Bicycle traffic and safety rules

1. Who protects the community's health?

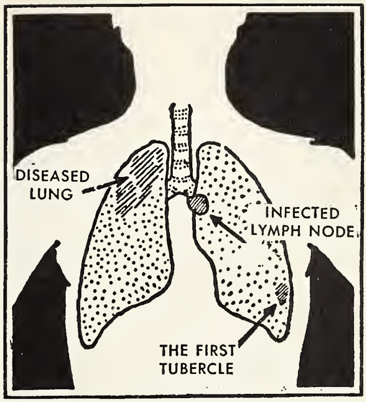
As you sit safely at your desk studying your science book, you are not likely to realize how many people and organizations in the community are engaged in protecting your health. You may know that your neighbor across the aisle was sent home with a sore throat by the school nurse. But you may not realize that the

nurse sent a sample of the germs causing the sore throat to the city health department to determine its cause. If the sore throat were contagious [kŏn·tā′jŭs], many people might be involved in preventing its spread to other people.

The health service of your school is but one of the many that constantly work to protect you from illness, injury, or death. The work of these various agencies can be divided into several large classifications: research to determine the cause of illness, education to inform people on how to use knowledge, prevention of disease by various means, and treatment. Each of these will be studied in this chapter.

Who carries on research in health problems? Almost any scientist who encounters a problem related to health may do some research to solve the problem. Research is a method of carrying on an experiment or investigation on a large scale. Often many people work on the same problem.

Such research may be carried on by the medical schools of large universities, by hospitals, by the armed services of the United States, by companies producing drugs, foods, and chemicals, by life insurance companies, by private organizations supported by gifts, and by doctors engaged in private practice. Every bit of knowledge which we have about health has come about as a result of experiment and research by some scientist or scientists.



National Tuberculosis Association

Tuberculosis, the most dangerous of diseases for teen-agers, forms small bodies called tubercles in the lungs. Lymph nodes filter germs from the blood and become infected.

An experiment to determine the cause of yellow fever was carried on by doctors of the United States Army in 1900. Two hypotheses [hī·pŏth′ė·sĭs, a working idea to be tested by experiment] seemed reasonable. One was that the disease was spread by materials discharged from the bodies of those ill with yellow fever. The other was that the disease was spread by mosquitoes.

To test these hypotheses, an experiment was set up. Three rooms were screened. Mosquitoes that had bitten yellow-fever patients were placed in one room. In a second room were placed bed clothes soiled by a discharge from a yellow-fever patient. A third room contained neither mosquitoes nor soiled bedclothes. A number of men volunteered to

U. S. Public Health Service

One of the most important tasks of the government is to study those diseases for which there is now no certain cure and to try to improve treatment for other diseases. This man is growing cancer cells for study.

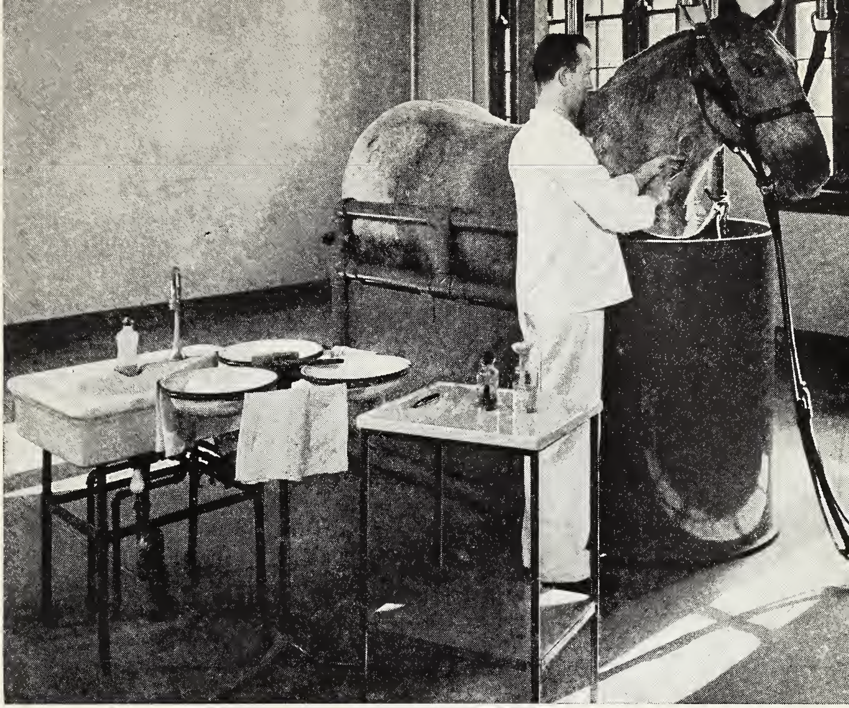
live in these rooms, knowing that they were risking their lives. The men lived in these rooms for several weeks. At the end of the time the men in the room with the mosquitoes were taken sick with yellow fever. Those in the other rooms escaped the disease. Thus it seemed probable that mosquitoes were the means of carrying yellow fever.

The information gained in this experiment was immediately applied to eliminate yellow fever. Several methods of controlling mosquitoes were worked out. Houses were screened to keep mosquitoes away from both those sick with yellow fever and those who were well. In two years the disease was brought so completely under control in Havana that during the second year there was not one death from the disease, where before many people had died. Similar results were obtained in other places. The disease disappeared entirely from the United States.

Research now in progress concerns prevention of tooth decay. It is believed that adding one part of the chemical element fluorine to each million parts of water will greatly reduce decay of teeth. You should consult your science magazines to learn about the success of this experiment. In 1946 five cities were adding fluorine to their supplies of drinking water. Careful records were kept of the number of decayed teeth in these cities. It may require many years to be certain as to the results of this experiment.

Who helps to educate the people about health? What you learn in school about health is important, but new discoveries may make some of it out of date. Many agencies help to spread new information about health.

You have probably heard discussions of public health problems over your radio. They are sponsored by city health departments, by medical schools, by organizations of doctors and dentists, and by commercial organizations. Several agencies of the United States government issue booklets dealing with such prob-



Eli Lilly and Company

Horses are used in the preparation of antitoxin used in prevention of diphtheria. The serum is drawn from the horse's body under the best sanitary conditions possible.

lems as caring for babies, providing good food, controlling insects, and other activities carried on at home.

A state or city health department may put on a drive against a certain disease. Everybody in the community is examined, and those found to need treatment are sent to doctors.

Special organizations provide information about certain diseases, such as cancer, tuberculosis, and infantile paralysis. You may have bought stamps or seals to help support these groups.

Many newspapers and magazines have sections devoted to health and medicine. Look in one of the latest news magazines for this information.

The law-enforcement officers sometimes must educate people to protect others. When you have a personal health problem, you usually consult your family doctor.

Who is responsible for preventing disease? Most of the work of your school health service is devoted to preventing the spread of disease. State and city health departments inspect milk supplies, restaurants, hotels,

Birds Eye Frosted Foods

Each chicken is examined by a government inspector before the final cleaning is begun. These chickens are being prepared for freezing.

public buildings, theaters, restrooms, and other places where people might catch some disease or be in danger. The work of supplying pure water and of removing wastes from houses is usually done by a separate department of the city.

Often years of research must be done before any kind of control for a disease is found.

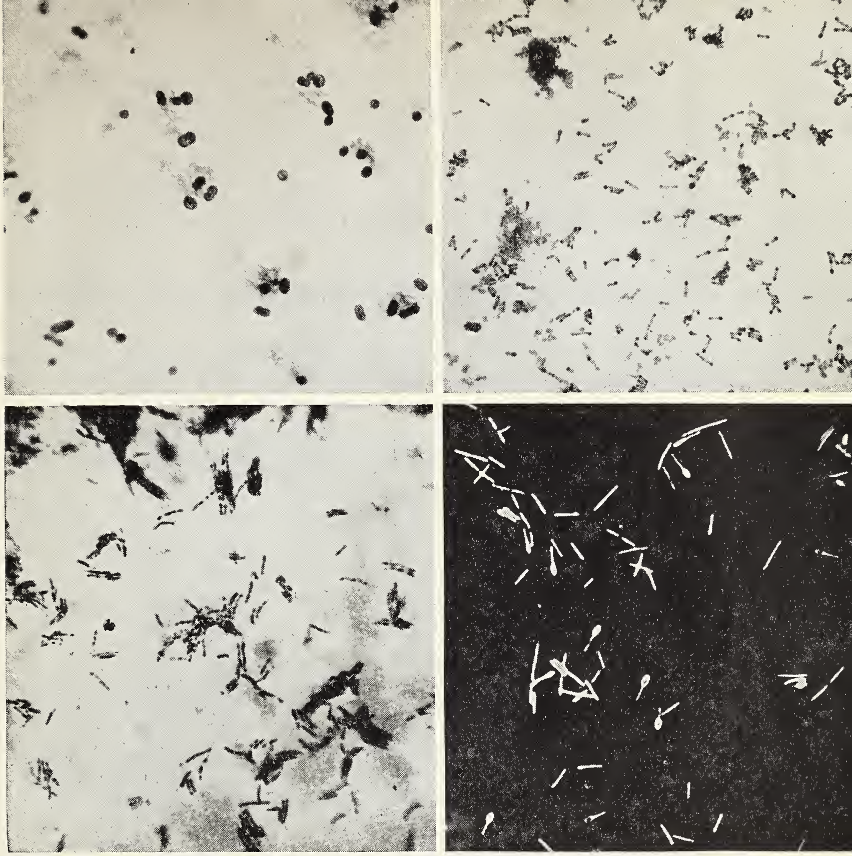
Another type of disease control depends upon use of drugs or vaccination or some other treatment to make the individual immune to certain diseases. Such work is done when the water supply of a region is made impure by floods. Often you may read dramatic stories of how thousands of typhoid "shots" are flown to a flooded region to prevent the spread of this disease. Some of this kind of work is done by private doctors, some by public health agencies.

Inspection of packing of meat is done by the United States government. The Pure Food and Drug Administration inspects shipments of foods and drugs, and sometimes prevents distribution of dangerous or unwholesome materials to the public.

Who cares for the ill? Most sick people are treated by private doctors. People having certain diseases are usually cared for by community agencies. Hospitals for those who are mentally ill are usually supported by the state. Tuberculosis sanitariums are often supported by public gifts. The Red Cross sometimes provides medical care for people. Most cities and many counties and states have hospitals, clinics, and doctors who care for those who cannot afford to pay for their own treatment.

What health records are kept? Three kinds of health records are especially important. Records of births and deaths give information about the size of the population. Records of causes of death are necessary for planning prevention and treatment of disease. Records of the kinds of illness and the amount of each kind serve the same purpose. Other records include number of places inspected, operations of various departments, and similar information.

Study of records of particular diseases is especially useful in preventing epidemics.



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These photographs, taken through a microscope, show four common disease-causing bacteria: At the top, pneumonia (*left*) and diphtheria. At the bottom, tuberculosis (*left*) and lockjaw.

Things to think about

Copy the following sentences in your notebook. Select the correct ending for each sentence.

1. A disease which is contagious is (*a*) fatal (*b*) catching (*c*) spread by mosquitoes.
2. A large investigation for solving a problem is called (*a*) an experiment (*b*) a hypothesis (*c*) research.
3. Yellow fever is spread by (*a*) mosquitoes (*b*) body discharges (*c*) impure air.

4. Tooth decay is probably caused by (*a*) impure water (*b*) germs (*c*) eating hard foods.
5. When you cannot catch a certain disease you are (*a*) immune (*b*) vaccinated (*c*) fortunate.
6. A disease carried by impure water is (*a*) yellow fever (*b*) cancer (*c*) typhoid fever.
7. Public health is protected by (*a*) individual doctors (*b*) many agencies (*c*) commercial firms.

2. What causes contagious diseases?

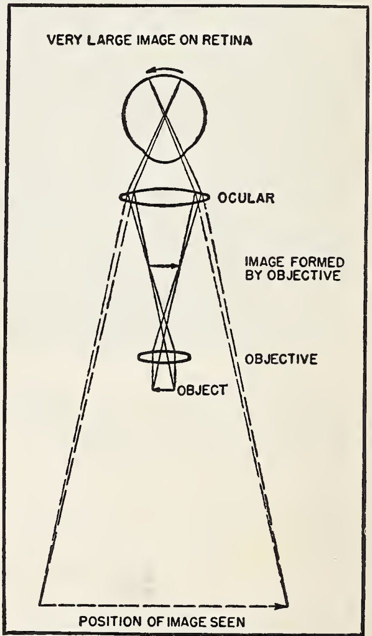
In order to know how to control contagious diseases, it is necessary that each disease be studied separately. Unless we know how a particular kind of germ lives and causes illness, we cannot be certain that we can prevent it from spreading.

The prevention of the spread of disease is a community health problem. The word germ may be applied to any kind of organism which may cause disease. There are several kinds of germs.

What are bacteria? Bacteria are one-celled plants related to molds and mushrooms. They depend upon other organisms for food. Most bacteria do not cause disease, but are either harmless or beneficial.

Bacteria are microscopic—that is, they can be seen only through a microscope. They are so small that from 10,000 to 50,000 of them laid side by side make a row only one inch long. Some bacteria are so small that there is room in a single drop of milk for as many bacteria as there are people in the United States.

Bacteria differ from each other in appearance just as larger plants do. Some are round, some are rod-shaped, and some are spiral-shaped, like the wire binding in your notebook. Scientists color them when they make microscope slides, and different kinds of bacteria absorb different colors. If you ever see bacteria



Bausch and Lomb Optical Company

This diagram shows how rays of light are bent by lenses of a microscope in such a way that a very small object seems to be very large. Study the lines carefully.

on a slide, remember that they are not naturally red, blue, or green, but are colorless.

An easier way to study bacteria is to make a culture, or "bacteria garden." The food is made by heating gelatin [jĕl′*ȧ*·tĭn] or some similar material in water. The mixture is poured into flat dishes, each provided with a cover. The dishes must be made clean by boiling. When the food cools, it becomes like a stiff jelly or gelatin dessert. The cover of the dish is then removed, and the culture food is exposed to some source of bacteria—the air, a dirty finger (all fingers are dirty), or a fly's foot. In a few days each bacterium which falls upon the culture forms a colony which appears as a white, gray, or brown spot. Sometimes colonies grow so thickly that they cover the culture completely.

Bacteria are found almost everywhere. They are able to keep up their large numbers because they multiply rapidly. They reproduce by cell division, which may take place in as little time as half an hour. By constant division, one bacterium may produce one million bacteria at the end of a 10-hour period.

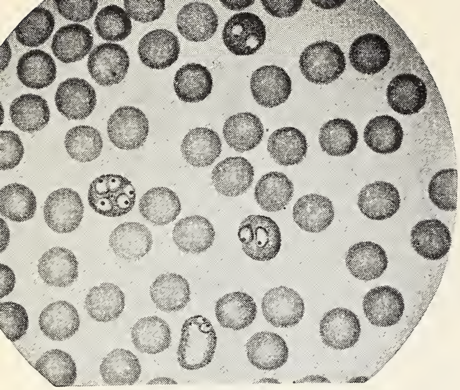
Bacteria may occasionally form spores which have thick walls. These spores can withstand high temperatures and drying which would kill ordinary bacteria.

Bacteria produce a large number of diseases, among which are typhoid fever, tuberculosis [tů·bûr′ků·lō′sĭs], and diphtheria [dĭf·thḗr′ĭ·*ȧ*].

What are viruses? Many common diseases are caused by substances made up of such small particles that they cannot be seen with ordinary microscopes. Among the diseases caused by viruses are the common cold, smallpox, chicken pox, infantile paralysis [ĭn′f*ă*n·tĭl p*ȧ*·răl′*ĭ*·sĭs], influenza [ĭn′flo͝o·ĕn′z*ȧ*], and yellow fever. No one knows whether these viruses are really living or not. They cannot grow, as bacteria can, on nonliving food, but they reproduce very rapidly in living tissue in the body. They may be very complex chemicals instead of living organisms.

What diseases are caused by animals? Among the animals that cause disease are certain worms and one-celled animals, or protozoa [prō′tȯ·zō′*ȧ*]. Malaria is caused by a one-celled animal that lives inside the red corpuscles [kôr′pŭs'lz, blood cells] of the blood.

Among the more common worms that cause disease are the hookworm, the porkworm, and the tapeworm. The hookworm disease is found in the southern states. The porkworm is a parasite that lives in two hosts: the pig and human beings. When pork which is not thoroughly done and thus contains these worms is eaten, a serious sickness may result. There are several kinds of tapeworms that may live in the intestines of man. Some reach a length of several yards. They may be found in fish, beef, or pork. The worms may live in



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The one-celled animals which cause malaria attack the red blood cells and cause the ill person to become weak. At times the disease causes chills and then fever.

the muscles of these animals. When the meat of these animals is eaten, these worms may become parasites in the intestine of man. Both the porkworm and the tapeworm are killed by a thorough cooking of meat.

How do germs cause disease? A different kind of germ causes each kind of disease. Germs enter the body in various ways. Once they are in the body, they live and grow there, and as they grow certain waste products, or toxins [tŏk′sĭnz], are formed which act as poisons in the body and produce disease. Some types of bacteria are found growing only in some certain part of the body. Diphtheria germs are usually found in the throat. In most cases of tuberculosis, the bacteria are found in the lungs. Other kinds of bacteria spread more generally throughout the body.

What are the sources of disease germs? The chief sources of disease germs are sick people. They may also come from animals. A sick person may be dangerous to others at three different times. When a person is first getting a disease, even before it is known that he is sick, he may give off disease germs. Germs are most often given off after one has the disease and is known to be sick. A third possibility is that even after a person has recovered entirely from the disease he may continue to carry the germs in his body and give them off. This situation is sometimes found in people who have recovered from typhoid fever and diphtheria.

How do disease germs leave the body? Disease germs may leave the body of sick people in a number of ways, depending upon the disease.

The germs of typhoid fever are given off in wastes from the body. Germs of smallpox and measles leave the body through broken-out places on the skin. Germs of diphtheria, whooping cough, and tuberculosis are given off in fluids and spray from the mouth. Mouth spray is the name given to fine drops of water given off from the mouth while talking, singing, or coughing. This spray may be thrown four feet by talking, while by coughing it may be thrown as far as 10 feet. Some fine drops may float even farther in the air.

How do disease germs enter the body? Some germs, such as those of typhoid fever and tuberculosis, enter the body through

the mouth in food and drink. Some germs, such as those of diphtheria and tuberculosis, enter through the nostrils or mouth in the air we breathe. Many kinds of germs enter the body through wounds in the skin. The germs of malaria [mȧ·lâr′ĭ·ȧ] and yellow fever enter the skin through the bites of mosquitoes. While the germs of disease may enter the body in more than one way, most germs enter through the mouth.

How may disease germs be spread? The chief means by which disease germs may be spread are by personal contact; through milk, water, and food; and by insects.

Transfer by contact usually takes place at short distances. Germs from a sick person may be transferred to a well person in the sickroom. The hands which come in contact with so many things may transfer germs to the mouth. Germs may be spread by a kiss, a cough, or a sneeze, or by a drinking cup.

Occasionally disease germs may be spread through foods. For example, many kinds of germs may be carried in milk that is not pasteurized [păs′tẽr·īz, a method of heating to kill germs]. Various worm-parasites [păr′ȧ·sīt, an organism that lives on another] may be taken into the body in meats that have not been thoroughly cooked. Flies may leave disease bacteria on uncovered food.

Malaria and yellow fever are carried by mosquitoes, and a number of diseases may be carried by the housefly.

The most important problem of community health agencies is to prevent germs from spreading. This can be done in several ways. Sick people may be kept away from well people. Carriers of disease may be controlled. Sources and supplies of food, water, milk, and clothing may be kept free from germs. And of course the individual may be encouraged to make himself immune to certain diseases.

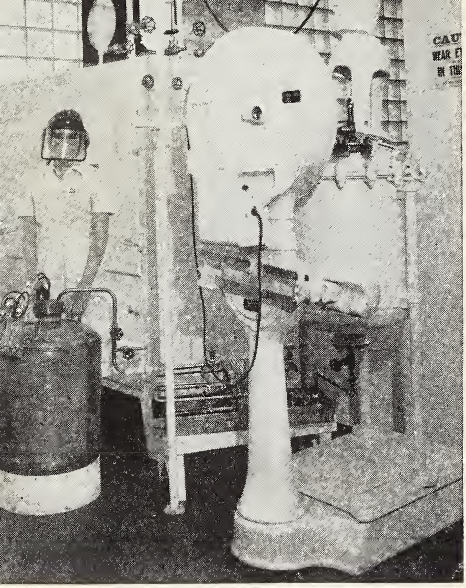
Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

Most catching diseases are caused by one of three types of germs —1—, —2—, or —3— in shape. Bacteria cannot make their own —4—. They reproduce by a method called —5—, and they are so small that they can be seen only by using a —6—. The poisons made by disease germs are called —7—. Tapeworms and porkworms in meat can be killed by thorough —8—.

3. How can contagious diseases be controlled?

It seems very simple to say that we can control contagious diseases by preventing the passing of germs from one person to an-



Commercial Solvents Corporation

Some diseases can be cured by the drug penicillin [pĕn′ĭ·sĭl′ĭn] which this woman is preparing for use.

other. But it is not easy to keep germs from spreading. Germs are invisible to the unaided eye, and there are a great many of them.

How can we kill germs? Unless germs find some host [a person or animal on which to grow] they die naturally. But many germs live a long time, and we cannot wait for them to die. In a room which has been occupied by a sick person there may be millions of germs. Dishes, handkerchiefs, and bedclothes used in the sickroom may be covered with germs.

One of the best ways of killing germs is by use of heat. If a dish is washed in soapsuds at 180 degrees F. and then dipped (not rinsed) in boiling water, it will likely be quite free from germs. Forks and spoons should be washed with special care. After a dish is clean it is better to let it drain than to wipe it. Germs may be transferred from dirty dishes to towels and then to clean dishes.

Washing clothing in hot water kills many germs. White clothes may be boiled. Bleaches used to whiten clothes are generally good germ-killers. Ironing clothes may kill germs.

There are certain chemicals called germicides which have been found to kill germs. Lysol and carbolic acid are examples of germicides. They are so poisonous that they are not generally used inside the body. Germicides are used for such purposes as sterlizing surgical instruments or killing germs in rooms where sick people have been living. Iodine is a germicide which is safely used on all fresh, open wounds. Boiling also will kill disease germs. If drinking water contains the germs of typhoid fever, the water can be made safe by boiling it.

Less active chemicals, which do not kill the germs but which merely lessen their activities, are known as antiseptics. Antiseptics in general are worthless, although they are falsely advertised and sold as germ killers.

Under certain conditions one of the best natural germicides is sunlight. As germs are blown about on the dust particles in the air and exposed to the action of sunlight, they are killed. Sun-

light will not kill germs in a cut. Freezing temperatures kill most germs, although some withstand freezing well. They live as spores for several weeks and then become active again under favorable conditions.

A good way of avoiding infection by bacteria is to wash the hands thoroughly with soap and water just before eating. If you will stop to think of all the objects your hands have touched since the last meal, you will readily see that there are many chances for germs to stick to the fingers. Those who handle food—bakers, grocers, and the girls and women in the home who prepare the meals—should scrub their hands often in strong soapsuds. Lunches which are prepared to be taken to school should be well wrapped in fresh waxed paper.

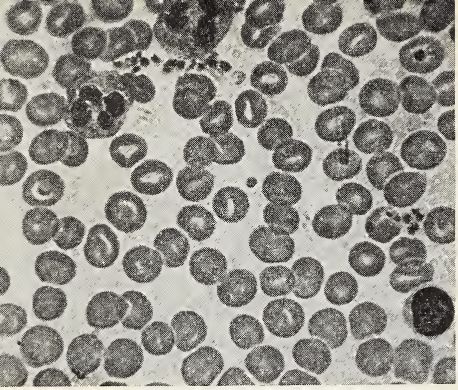
Washing not only kills germs but also removes materials on which germs grow. Many boys and girls have pimples, partly because they do not wash off the oil which comes from glands in the skin. These glands become active as you mature. Only a strong soapsuds applied two to four times a day will remove this excess oil effectively.

So that each person may have a clean towel to use, separate towels are required by law in public places. Even in the home it would be well if more care were taken about the matter of separate towels.

How can we avoid giving germs to other people? Not only should you be careful to protect yourself from disease germs, but you should be thoughtful of others and avoid exposing them. Following are some of the things you can do or avoid doing: (1) Do not cough or sneeze into people's faces. Turn the head away and hold a handkerchief in front of the face. (2) Do not spit in public places. (3) Do not handle food in a grocery store or bakery. (4) At the table, do not handle food that is to be eaten by someone else. For example, do not break a slice of bread in two and return one piece to the plate. (5) Pass spoons, forks, and knives by the handles. (6) Be careful about waving or needlessly displaying handkerchiefs. (7) Keep your hands away from your nose and mouth. (8) Do not shake germs from your handkerchief into the air.

Should sick people be isolated? Some diseases are most contagious before the victim knows he is ill. These diseases are particularly difficult to control, because the person who is spreading germs does not know that he has them. Most diseases are contagious while the person is actually ill, the length of time depending upon the disease. Certainly a person who is capable of spreading disease should be kept away from those who are well.

In the case of certain catching diseases the sick person is forbidden to leave his house for a certain length of time. A card is placed on the house by the health officer giving the name of the dis-



© General Biological Supply House

When viewed through a microscope the blood cells or corpuscles become visible. The red corpuscles are flattened disks, while the white corpuscles are larger and irregular in shape.

ease and warning other people to keep away. The purpose of this quarantine [kwŏr′ăn·tēn] is to prevent the spread of disease and thus save lives. The strictness of the quarantine varies according to the ease with which the disease is spread. Only a strict quarantine protects against such diseases as smallpox and diphtheria because they are spread very easily. Such diseases as typhoid fever do not need quarantine because they are not spread directly from person to person. Sometimes it is necessary to quarantine not only sick people but also those who have been exposed to the disease.

After disease germs enter the body, a period of several days or weeks follows before the person becomes sick. This time is called the incubation period. The length of this period varies with the disease, ranging from two or three days for some diseases to three weeks for others. A person who has been exposed to certain diseases may give the disease to other people during this incubation period. Therefore people who have been exposed must be kept under quarantine for a length of time equal to the incubation period.

The common cold is contagious at all times, but is most contagious just as it is appearing. When you are catching a cold, you should stay at home.

Tuberculosis is contagious at all times. If a tuberculosis patient remains at home, he will be very likely to infect most of the other members of the family. Ordinary safeguards are not effective for a long time against a huge supply of germs. Tuberculosis patients are best treated in a sanitarium. There they not only receive better care than is possible at home but will not infect others.

Are some people carriers of disease? There are some diseases which may linger in a person's body for a long time without making the victim noticeably ill. Typhoid fever is such a disease. The person who has the disease may unknowingly spread germs to others. Such a person is called a carrier.

When a carrier is discovered, he should first be prevented from handling food, milk, water, or other things which might spread germs. Then, too, he should be given treatment to try to get rid of the germs remaining in his body. Most states have laws requiring handlers of food to have regular medical examinations.

DEMONSTRATION: HOW DO BACTERIA GROW?

What to use: Four ounces gelatin, 1 ounce beef extract, salt, soda, five Petri dishes, forceps, pan, burner, and stand.

What to do: Boil the dishes and forceps almost the entire class period. Put the gelatin and beef extract with a pinch of salt and of soda into a quart of water and boil. When the liquid is clear, pour it into the hot dishes which must be set level. Cover the dishes immediately. Permit them to cool. Handle the dishes only with the forceps.

When the dishes are cool, follow these instructions: (1) set one aside for comparison; (2) open one an instant and cough over it, and quickly cover it; (3) open one and touch the gelatin with the finger, and cover it; (4) open one and shake a janitor's mop near it, and cover it; and (5) put a drop of water on one, shake it around, and cover it.

Keep all the dishes where the temperature will not go below 70 degrees F. Be sure that you label them so they can be recognized.

The organisms which are growing on this culture are the cause of athlete's foot, an infection of the skin. The food is held in a Petri dish.

When you are done with the cultures, drop the Petri dishes into boiling water and leave them for 15 minutes before washing them.

What was observed: Observe on which dish spots first appear. These spots are growths of bacteria. A great many bacteria make up one spot.

What was learned: What was learned about the places in which bacteria are found? Why were the Petri dishes dropped into boiling water?

Things to think about

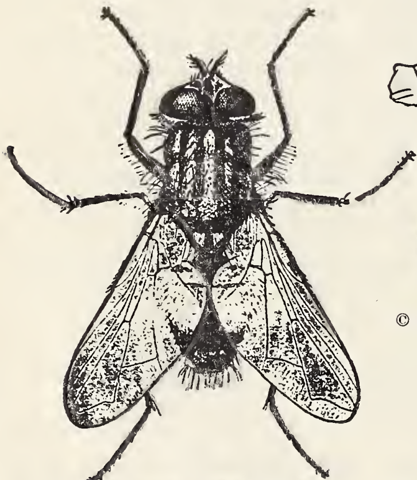
Copy the following paragraph in your notebook. Complete the sentences.

Germs on dishes can be killed by washing in hot —1— and by dipping them in —2— water. A small amount of drinking water may be made safe by —3— it. A chemical such as iodine which kills germs is called a —4—. People who handle food should keep their —5— clean. Outdoors many germs are killed by —6—. You should use a —7— to cover your mouth when sneezing. The time during which a disease develops in the body is called the —8— period. A sick person should be —9— during the time he can spread the disease. A person who has recovered from a disease, but who can still spread it, is a —10—.

4. How are insect-carried diseases controlled?

There are many diseases which can be carried by insects and other related small animals. Among them are tuberculosis, typhoid fever, yellow fever, malaria, spotted fever, plague, and typhus. While these diseases are not familiar to you, the reason is that your community health safeguards are working. If they fail, you might find them all too familiar for safety.

Why are houseflies dangerous? The living habits of the housefly make it one of the most dangerous of animals. The female fly lays her eggs in filth. The larva or maggots live in filth. Adult flies eat filth as their regular diet. But they also eat the same things that people eat. The fly that alights daintily on your food may have been in a garbage can or outdoor toilet ten minutes before. Particles of filth cling to the feet, the mouth parts, and the entire body of the fly. In this filth there are many germs, perhaps millions of them. The germs that are carried to your



© Central Scientific Company

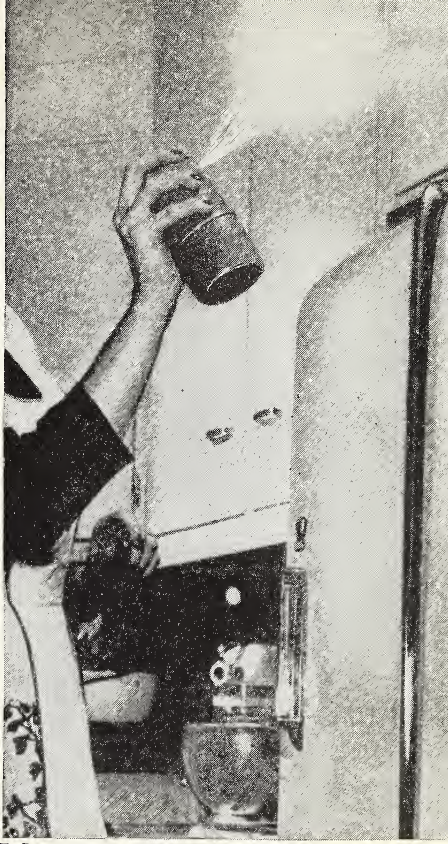
The common housefly looks harmless enough. Above are the maggot, or larva, and the pupa. At the lower left is the foot of the fly, showing the germ-carrying pads. The larva and pupa grow in filth. The adult fly alights on filth and feeds on filth. No place where flies breed can be considered clean.

food supply may grow in large numbers. Milk, custards, cottage cheese, moist bread, boiled ham, and other foods provide good places for growing bacteria.

A fly can carry almost any disease caused by germs given off from the human body. Garbage may contain materials that have been in contact with the mouths of sick people. Body wastes contain several kinds of germs. Wastes spit upon sidewalks also contain many germs. Flies collect and carry germs from these sources. Tuberculosis, typhoid fever, infantile paralysis, dysentery, and many other dangerous diseases may be carried by flies.

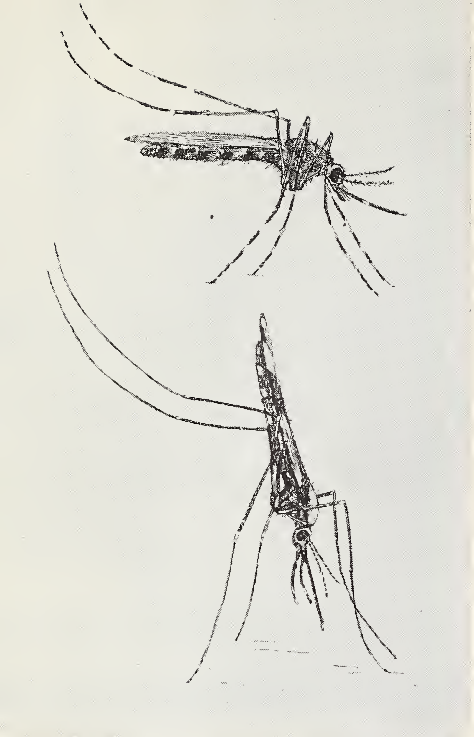
How are houseflies controlled? If we could keep our cities and farms absolutely clean there would be no houseflies. But we cannot seem to do so. As long as people put garbage in outdoor cans and use outdoor toilets and unsealed sewers, there will be flies. Wastes from dogs and farm animals also provide breeding places for flies. Even so, there is no excuse for not keeping our cities as clean as possible. We should constantly strive to improve cleanliness in every possible way. If they are not controlled by other means, the number of flies in a given place in midsummer is a good indication of the amount of filth in the neighborhood.

The most effective single control of flies, except cleanliness, is use of DDT, or some other insect killer. Chemicals often are sprayed on all surfaces where flies might be expected to alight. Commercial insect killing organizations and city health departments apply DDT in a fine fog which is harmless to people. The areas around restaurants and food handling areas, creameries, home garbage cans, outhouses, and other sources of food for flies are sprayed. In addition it is effective to spray window and door screens with DDT in kerosene.



E. I. du Pont de Nemours and Company

Many kinds of insects are household pests unless controlled by an effective spray. Sprays should not fall on food.



U.S.D.A.

The malaria-carrying mosquito (*below*) stands on its head when it sucks blood from its victim. The common mosquito rests with body parallel to the surface it stands on.

In several cities where this treatment has been used flies have practically disappeared.

Use of screens is still important. Restaurants, dairies, bakeries, hospitals, outdoor toilets, and private homes should be well screened.

How do mosquitoes carry diseases? Insects do not cause diseases, but they do carry the germs that cause the diseases. Mosquitoes spread disease germs by biting people. Only female mosquitoes bite people. When a mosquito bites a person, she pierces the skin with a sucking tube. Then she forces into the wound a tiny drop of saliva [sȧ·lī′vȧ] from her mouth to keep the blood flowing. Then she sucks up some blood.

In order to carry disease the mosquito must bite two persons, a sick person and a well person. When it bites a sick person, it takes into its body some blood containing the germs that cause the disease. In the malarial mosquito the germs pass through several stages of development in the mosquito's body and finally come to rest in the salivary glands [tissues producing saliva] of the mosquito. When the mosquito bites a well person, the saliva containing these germs is forced into the person's blood. These germs then attack the person.

The cause of malaria is a one-celled animal; the cause of yellow fever is a virus. There are many different kinds of mosquitoes. Not all kinds carry disease. The kinds that carry disease are found chiefly in the southern states. People who live in the South must be especially careful to avoid these mosquitoes.

One kind of mosquito carries yellow fever, but several kinds carry malaria. The yellow-fever mosquito breeds in water around houses and does not fly far. Some malaria-carrying mosquitoes fly considerable distances. Some malaria carriers breed in pools of water, some in damp grass, and some along margins of streams.

How are mosquitoes con-

Warner Brothers, First National Pictures

This scene from the motion picture "The Life of Louis Pasteur" shows the famous anthrax experiment, in which some sheep were inoculated and some were not. Those inoculated lived; the others died from anthrax. The camera shown is of the type used then. The sign would have been French, of course.

trolled? The yellow-fever mosquito can be controlled by drying up all stagnant water around dwellings. If water cannot be removed, it can be covered with a thin film of oil. The oil suffocates the mosquito larva, or wigglers, which live just beneath the surface of the water. DDT is effective against mosquitoes, but it tends to kill fish and other kinds of life when sprayed on ponds.

It is difficult to eliminate the malaria-carrying mosquitoes. Draining swamps in areas around dwellings and particularly around cities is of great value. Spraying grass and water kills many mosquitoes.

Houses in malaria-infected regions should always be screened. It is important to cure those people who are carriers of malaria, for they provide the germs which are spread to others. If carriers live in screened houses, they are less likely to be bitten by the germ-carrying mosquito. A fine-mesh screen is required to keep out mosquitoes. If a coarser

screen is sprayed with DDT in kerosene, the mosquito may enter, but it will die before it can carry the disease to another person.

Do fleas and lice carry disease? Two extremely dangerous diseases, typhus (not typhoid) and plague, are spread by the bites of fleas or lice.

The fleas which carry plague live most of the time on rats. In order for the plague to be spread the flea must bite an infected person or rat and must be carried by a rat to another person. Plagues occur in countries where many people live crowded together in filthy conditions and where houses are so poorly built that rats can enter easily. Rats are very common, and if a plague should start it would be difficult to control. Another type of plague is carried by fleas found on squirrels and mice.

Typhus is spread by body lice. Lice pass from one person to another, carrying germs. They are common where people live under unsanitary and crowded conditions. Cleanliness and DDT or some other good insect powder will control lice.

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

The number of persons a mosquito must bite in order to carry malaria is —1—. The water stages of mosquitoes are called —2—. A common name for the stage of flies found in breeding places is —3—. Malaria is caused by a —4— celled animal. Yellow fever is caused by a —5—. Germs that cause plague are carried by fleas which live on —6—. —7— are the only means by which malaria and yellow fever are carried. To prevent mosquitoes from laying their eggs, swamps should be —8—. Mosquito —9— may be killed by spraying kerosene on their breeding places. Yellow fever has been controlled by fighting the —10—.

5. Can the community prevent sickness?

While most of the work of preventing illness is done by the various agencies of the community, it is the individual who becomes ill. Whenever it is possible, it is best to be sure that the individual is immune to as many diseases as possible. In the case of some diseases which cannot be prevented, early discovery makes treatment much more likely to succeed.

Does the body have natural defenses against disease? Some of the natural defenses of the body against disease are present at all times. Other defenses develop only after the disease has made some progress. The skin serves as a protection to keep disease germs from entering the body. But even if disease germs do enter the body, it does not follow that we are going to be sick, for the body

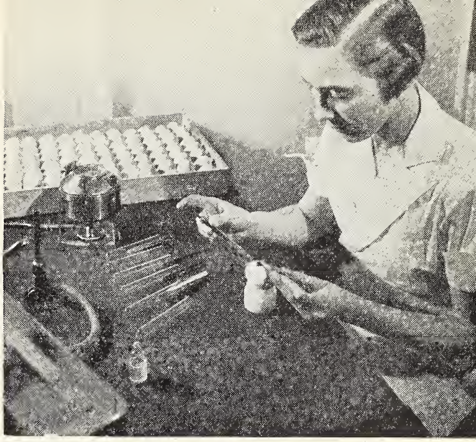
has ways of fighting germs. In most cases the body does its work so well that we are not sick at all and do not even know that the germs have been there.

There are two main ways in which the body defends itself. One way is by the white blood corpuscles, which attack germs and destroy them. These corpuscles are found in the blood which carries them to all parts of the body. They can pass through the walls of the blood vessels if necessary. The pus [pŭs] found around infected sores and cuts is composed partly of dead white corpuscles which have been overcome while attacking germs.

As another means of defense, the body makes substances known as antitoxins, which protect us from the effect of the toxins, or poisons, made by the germs. In the case of diphtheria one kind of antitoxin is made. In the case of lockjaw another kind of antitoxin is made.

When a person recovers from certain diseases, he is rendered immune [ĭ·mūn′] to them—that is, he will not get them again. When a person is sick, the body makes certain substances which protect him from a second attack. For example, a person will not usually get scarlet fever or smallpox a second time.

Fortunately it is not necessary for living disease germs to enter the body for us to develop immunity to some diseases. Certain materials called vaccines or serums may produce the same result.



Eli Lilly and Company

To prepare the vaccine used for preventing smallpox, the virus which causes smallpox is put into the egg when the chick is developing.

Does vaccination prevent smallpox? In most communities smallpox is now a rare disease. Yet it was one of the worst diseases of former times. The proof is positive that vaccination has been the chief means of reducing the death rate from smallpox. It still remains the only effective means of controlling that disease.

In the process of vaccination there is introduced into the skin a substance, called a vaccine [văk′sēn], which causes cowpox. Formerly this vaccine was obtained from calves raised for this purpose. More recently eggs are used. The eggs are first incubated for about two weeks. The embryo chicks are then inoculated [ĭn·ŏk′ū·lāt, to put germs into the body] with the virus. The vaccine thus obtained from the chicken eggs is used for vaccination.

When vaccine is introduced into the body, the body begins to manufacture substances (antitoxins) to offset the effects of this vaccine. Some of these substances are left in the body after the effects of the vaccination pass off. Just as these substances overcame the effects of the cowpox germs, so they overcome the effects of the smallpox germs which may enter the body. Epidemics of smallpox occur usually because many people have neglected to have themselves vaccinated.

How is diphtheria controlled? Of more recent origin is the conquest of diphtheria, a disease which is especially dangerous to children. During the last 50 years the death rate from this disease has been greatly reduced. In 1900, the death rate per 100,000 was 42; today it is less than one per 100,000 per year.

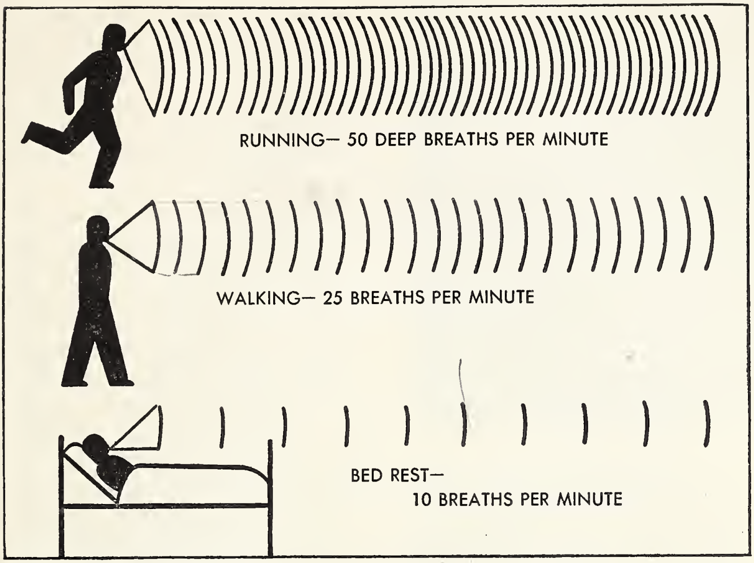
The conquest of diphtheria has been brought about partly by the use of antitoxin. It is prepared from horses which have been given a mild form of diphtheria by the injection [ĭn·jĕk′shŭn, forcing in] of toxin into their blood. As a result, a large amount of antitoxin is made in the blood of the horse to offset the effects of the toxin. Some blood is drawn from the horse in a painless fashion. Some of the blood fluid containing the antitoxin is put into the blood of a person sick with the disease. This antitoxin offsets the effect of the poisons made by the germs. If this treatment is applied in time, it is almost a sure cure for the disease. The earlier it is taken, the greater the chance of recovery.

In one way the principle involved in the treatment for diphtheria is different from that involved in vaccination for smallpox. In the treatment for smallpox the human body makes its own antitoxin as a result of vaccination. In the treatment for diphtheria the antitoxin is made by the body of a horse and is later injected into the human body.

It is now possible to keep children from having the disease at all. This is accomplished by injecting under the child's skin a substance known as toxoid. Some children are naturally immune to diphtheria. By means of a simple test, it is possible to find out whether a child is immune or not. If he is not immune, he should be inoculated to prevent the disease.

What other disease can be prevented? The test for scarlet fever is similar to the test for diphtheria. If the test shows that a person is not immune to the disease, an antitoxin treatment may be given which gives immunity for a short time. During epidemics it is of great value.

Most people are not inoculated against typhoid, although it is the best possible protection. Every soldier is inoculated. Protection of the milk and water supplies often is enough protection against typhoid. Formerly typhoid was often spread through contaminated drinking water, but since cities have provided a



National Tuberculosis Association

Rest in bed is needed by persons with tuberculosis because rest of the body gives the lungs less work to do and the best chance to get well.

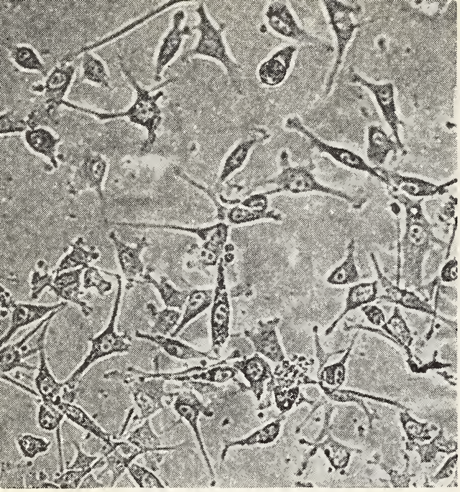
supply of pure water, the death rate there has declined. If you go camping you should be inoculated.

Measles is also preventable by use of inoculation. The material used is made from human blood. You have probably heard of blood banks where a supply of blood is kept to be injected into the bodies of those who have lost blood, or whose blood is not normal. From this stored blood it is possible to make a material containing the chemicals which made the blood-givers immune to measles. These people had measles and became immune. Children may now be saved from the serious dangers of measles by use of this blood material.

What diseases must be discovered early? Three of the most deadly diseases, tuberculosis, cancer, and heart trouble, cannot be prevented by any known method of immunization. But they may be cured if discovered in time. Careful examination of every person every year or two is necessary to detect these diseases. Until these diseases are fairly well advanced there may be no noticeable symptoms.

Your school doctor or nurse usually makes an examination of your heart by listening to its beating. An unhealthy heart does not beat regularly in the same way that a normal heart does.

The usual method of checking for tuberculosis is by use of the



U. S. Public Health Service

These cancer cells have been grown in a laboratory for study. A cancer cell seems to be a body cell which has grown out of control and endangers the life of the body.

chest X ray. A picture of the interior of the chest is taken, and the picture is examined by an expert in finding symptoms of tuberculosis. If a person seems to have the disease, other examinations follow. If the disease is present, the patient is sent to a sanitarium. Tuberculosis is the most deadly of all diseases to teen-age persons.

Cancer may be fairly far advanced before it can be detected by feelings of pain. New tests which depend upon using samples of the blood are being developed for discovering cancer in the body. A very careful general examination may be necessary to locate the cancer if it exists. If you find any unusual lasting soreness of any body opening or have any unusual growth on your skin you should go to a doctor for an examination.

Examinations to discover these deadly diseases may be provided free of charge by some community organization. If you have an opportunity to have such an examination, you should take it.

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

—1— can be controlled by vaccination. As a result of vaccination the body makes —2— which offset the effects of the disease germs. If used in the early stages of the disease, diphtheria can usually be cured by the use of —3—. Tuberculosis is caused by a —4—. Diphtheria antitoxin is obtained from the blood of —5—. Typhoid fever in armies is controlled by —6—. A hospital devoted especially to the care of tuberculosis patients is called a —7—. The disease most commonly spread by impure drinking water is —8—. Teen-age people are in special danger from —9—.

6. Can we safeguard our food supply?

Any kind of food may carry disease germs. Any place where food is served may be so dirty that the food is made unsafe.

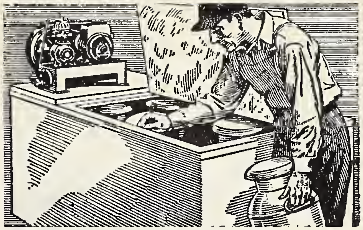
Certain foods may be contaminated at their source or in handling.

How do we obtain safe milk? Milk is an excellent food, but it may carry several kinds of disease germs. Among diseases which are known to have been carried by impure milk are diphtheria, scarlet fever, typhoid fever, and tuberculosis. Milk as it comes from the cow may not be safe, since the cow may carry the germs that cause tuberculosis, a fever, or a severe sore throat.

One standard for judging the purity of milk is the number of bacteria it contains. An unusually large number of bacteria, even of the harmless kind, indicates that the milk has been carelessly handled. The standards set by different cities vary, but clean milk properly cared for will have a much smaller number than this standard.

Clean and well-regulated dairies are required to meet certain standards. The health of the cows should be properly looked after, for some cattle may have tuberculosis. A test has been worked out whereby cattle in a herd which have this disease may be detected. Such cows should be removed from the dairy herd. The barn should be properly built and cared for. For the sake of the health of the cows, the barns should be well ventilated and have the proper amount of light. They must be kept spotlessly clean.

If the milking is done by hand,



General Electric Company

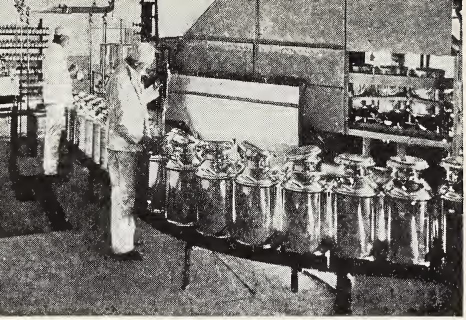
Milk is cooled on the farm by putting the cans in water kept cool by a refrigeration system.

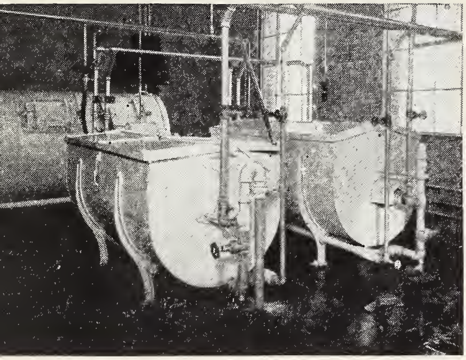
small-top milking pails should be used. Experiments have shown that many more bacteria are found in the wide-open pail than in the narrow-topped pail. It is very important that the pails should be thoroughly cleaned after use. Pails are best sterilized [freed of germs] by the use of steam.

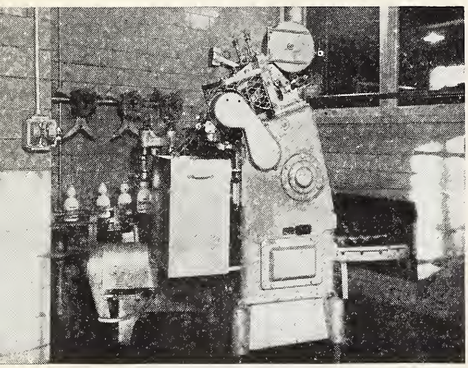
About 10 or 15 minutes before milking, the belly, sides, and udder of the cow should be cleansed with a damp cloth. All parts of milking machines must be completely cleaned after use. Workers in dairies should be required to take health examinations.

If milk is allowed to stand at ordinary temperatures, the bacteria multiply with great rapidity. The milk should be cooled at once to a temperature of 50 degrees F. or lower and it should be kept cold until it is to be used.

Certified milk is the name given to the safest and cleanest raw milk that is produced. Although certified milk costs more than pasteurized milk because of the expensive care which it has







Irradiated Evaporated Milk Institute and Marigold Dairies, Inc.

Milk comes from farms in cans (*top*), is pasteurized in tanks (*center*), and is bottled for distribution (*bottom*).

received, it still is not as safe as pasteurized milk. In the process of pasteurization the milk is heated at a temperature of about 145 degrees F. for a period of 30 minutes. This heating kills disease germs. At 137 degrees F. typhoid and diphtheria germs are killed, and at 139 degrees F. those of tuberculosis are killed. In another method of pasteurizing, known as the flash method, the milk is heated at a temperature of 150 degrees F. for a shorter time. The milk is then cooled at once to 50 degrees F. Although the chief effect of the pasteurization is to kill disease germs, a commercially important advantage is that the milk keeps longer without souring.

We have seen that clean milk can be produced only if proper attention is given the dairies. But there are so many dairies supplying milk to large cities that it is very difficult to inspect them all. Furthermore, some milk must be transported so far that it may be from 12 to 36 hours old by the time it reaches the consumer. These are sources of danger to health. Only because pasteurization is coming into general use is there a decrease in the number of diseases carried by milk.

How is milk delivered? Milk is collected from dairies by truck. The milk is generally carried in large cans to the collecting center. There it is cooled. It may be pasteurized at the collecting center, or the raw milk may be shipped to the city where it is to be used. In smaller communities milk is still shipped in cans. Milk is shipped to such large

cities as New York and Chicago in tank trucks. These tanks are so well insulated that the milk remains cool for a long time. The tanks are made of stainless steel. A tank may hold from 2000 to 3000 gallons of milk.

Delivery of milk in the city is made in the familiar bottle. Bottles may be of glass or of paraffin coated cardboard. Glass bottles should have a cover which fits completely over the top, so that the surface over which the milk is poured remains clean. Milk is delivered in trucks usually kept cool by ice.

E. I. du Pont de Nemours and Company

Wrapping food in attractive packages is one way of protecting it from dirt and germs.

How may foods be protected? When we buy food, we have a right to expect that it shall be fairly free from bacteria. Meat should be taken from the bodies of healthy animals killed under sanitary conditions. Then it should be immediately put into cold storage, and handled only when it is frozen or at low temperatures. Meat shops are required to keep the meat at a temperature only slightly above freezing.

Certain bakery goods, especially custard pies and soft cakes, are excellent places for the growth of bacteria. If these foods are not kept carefully covered and under the most sanitary conditions, they may not be fit to eat at all.

Ice cream is another food that may be impure. If old ice cream is sent back by the storekeeper, it may be filled with chocolate to disguise the stale taste and returned for sale. So you may be getting ice cream several weeks old. But, if ice cream is sold fast, kept fresh, and never returned, it is usually good.

Oysters may contain bacteria from dirty water in which they grow. Meat may contain parasitic worms. These foods require thorough cooking. Vegetables may be covered with bacteria from the soil or from careless handling. Vegetables eaten raw should be thoroughly washed. Raw fruit should be peeled or washed with great care not only to remove bacteria but to get rid of insect spray.

Manufacture and canning of food should be watched with care by government agencies. Sometimes government inspectors find partially spoiled materials, hairs, and fragments of worms in almost any kind of food. If the food is thoroughly cooked, these impurities are less harmful.

Are restaurants always clean? You may not think, when you go to the corner meeting place for ice cream, that you may be buying a good collection of germs. Soft-drink places, ice cream parlors, and restaurants must be clean to prevent spread of disease.

Some evidences of uncleanliness are easily observed. You can see grease around stoves. Cockroaches running on the kitchen floor are noticeable. Lipstick on the edges of glasses provide proof of careless washing. Any odor of stale grease or sour milk warn you away from an eating place. The presence of flies is evidence of carelessness. Unless the table top is spotless there may be germs along with the dirt. Any restaurant operator who really wants to protect his customers should welcome inspection of his kitchen and refrigerator by any person who is serious about wanting to protect his health. Is your corner-store man willing and able to keep things clean? Numerous inspections have shown that most food places are not always as clean as they should be.

Dishes are too often carelessly washed. A so-called antiseptic solution is often substituted for hot water and soapsuds. One of the worth-while jobs your gang might do is to look over neighborhood places and find the one which is safest. If you find none, you might tell your parents about what you discover.

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

Milk is a good place for —1— to live and grow. Disease germs in milk can be killed by the process of —2—. —3— milk is milk that has been produced under the most sanitary conditions. By means of a test it is possible to find out which cows have —4—. As soon as milk has been pasteurized it is cooled to a temperature not to exceed —5— degrees F. The purpose of pasteurization is to kill —6— germs. People who have —7— diseases should be prohibited from working in dairies. In pasteurization, milk is heated to a temperature of —8— degrees F. for a half hour.

7. Can we live in safety?

Although school children are often ill, there is no single disease which causes so much unhappiness and death as do so-called accidents. There is almost no place you can go or anything you can do that might not cause you serious injury. You can fall by jumping carelessly on a loose rug. You can choke by laughing while eating. You can push a pencil point into the roof of your mouth. You can fall downstairs. You can burn yourself in many ways. On the street your life is constantly in danger. And the

playground certainly is not a safe place.

With so many dangers facing you, you may think that the best thing to do is to avoid all kinds of activity. That is not really necessary. There are three factors which will greatly increase your safety. The first of these is a good attitude toward taking care of yourself. The second is to provide the safest possible living conditions at all times. And the third is to learn the necessary skills to live safely.

How does mental attitude affect safety? A person who feels sure of himself, gets along well with others, and is cheerful and happy is not very likely to have accidents. Many accidents are caused by showing off. You probably know some boy or girl who seeks the reputation of being the bravest member of the gang. Such a person may try to swim outside the ropes of a safe beach. He may try to walk along a high wall. He may go skating when the ice is not safe. He may play tag on the street in traffic. He may hook rides on trucks. Such a person does these stupid things because he is afraid that other people look down on him. He is afraid he will not be accepted by the group. Sometimes several boys of this type will get together in a gang, and will make a habit of playing reckless and foolish games. If you find yourself a member of such a group, the sensible thing is to get out of it. The other members may try to shame you and laugh at you, but it is easy to find friends who are normal instead of mentally upset.

American Red Cross

Are you reasonable and self-controlled in your behavior, or are you constantly in danger or difficulty because you do stupid things? Have you the show-off habit like this foolish boy?

Some people have accidents because they rebel against authority. These people do not obey traffic signals. They run in school halls. They play roughly around the swimming pool. They strike other pupils who are not prepared for rough play. They carry dangerous things such as knives, explosives, and other forbidden materials. Children normally outgrow this stage of rebellion against authority at age three or four, but these rebellious older children (and some grownups) are still childish in their reactions.

Some people unconsciously try to have accidents. If they are injured they feel that they cannot be expected to keep up with others, and so have an excuse to escape responsibility. A boy who falls on the cinder track expects

National Board of Fire Underwriters

These four pictures show common mistakes which lead to serious fires, and sometimes to death of people. Explain what is done wrong in each picture.

sympathy for his injuries, instead of blame for failing to win. A football player who knocks himself out with an awkward tackle can escape the hard work of playing the game. A girl who faints in class may escape having to recite when she is unprepared. A cut finger may be an excuse to get out of doing dishes.

People who have accidents because they are emotionally or mentally unwell need two kinds of help. One is treatment from a doctor, the school counselor, or other expert in finding the hidden causes of the person's disturbed feelings. The other is specific training in doing things as normal children do. A normal child thinks of what may happen before he acts.

Can our surroundings be made safer? The chief kinds of accidents in our homes are falls and burns. We can make our homes almost free from such accidents by careful planning. We can keep the shades up so that we can see well to do our work. We can keep all stairways clear and well lighted. We can always have a light when we walk around at night. We can get rid of loose rugs or fasten them down. We can finish our floors so they are not slippery. We can climb only on safe ladders, instead of on chairs or weak boxes. We can avoid rough play where there is not room for it.

To avoid fires we must have the heating system kept in good condition. We should never use an open flame where it is not safeguarded. We can avoid play-

ing with matches, making fires in playhouses, and using candles instead of flashlights. Smoking is a common cause of serious burns.

The handles of kettles of hot foods on the stove should be turned away from people who are working near by. Hot kettles should be handled only with pads. When someone is pouring hot water, others should keep well away from him. The kitchen is not a safe place to play.

We should never keep loaded guns, explosive liquids such as gasoline, sharp tools, or toys with wheels in the house. A bicycle propped in the hall may start to roll as somebody goes past, and may be as dangerous as a gun.

These examples show that common sense is required to make things safe. Almost anyone who spends some time thinking can find a number of ways to avoid having things fall, catch on fire, or otherwise cause injury around the house.

Can we learn to do things safely? A good many accidents result from failure to use ordinary equipment correctly. A saw, an ax, or a chisel is safe if it is used properly. You should have someone teach you how to use these tools. A person who understands guns loads his gun only when he is ready to shoot and unloads it as soon as he knows he will not need to shoot. Even then he will not be careless with it. Many people are killed because somebody forgot to unload the gun or because the shell stuck when the gun was supposed to be unloaded. Nobody who understands guns will ever point a gun at another person or at himself.

At the swimming beach a person who knows how to swim properly will never take chances on going where he is not sure he can get back safely. He will not dive into water unless he can see that it is clear of rocks, weeds, wires, and other dangerous things. He will look at the beach to see if it is free from broken glass. These things a lifeguard takes for granted. You probably cannot swim or protect yourself as well as a lifeguard can.

On the football field a player wearing a uniform and tackling according to directions of a good coach is not too likely to be injured. But if you decide to play football with a book, making your tackle without a uniform while running on the sidewalk, you can expect to be hurt.

You know that there are laws governing the use of bicycles. Do you know the laws? Can you ride well enough to control a bicycle at all times. Do you always ride with just yourself on the bicycle? You know that a street filled with traffic is no place to practice riding a bicycle. And nobody should ever drive an automobile on the street until he has learned how to drive in a safe place and has passed a driving test.

Learning how to do things right may seem to be tedious and unnecessary. When you are twelve to fourteen years old you know how to do so few things, and want to do so many, that you

may be inclined to take chances doing things which you cannot do well or safely. You will have more fun and will live more safely and longer if you learn how to do things right.

Certain school subjects have much more value in helping you to learn to live safely than do others. In science, shop courses, home economics, and gymnasium and athletic games you have a good opportunity to learn skills and to practice them under safe conditions. During the remaining years of school ahead you should include these practical courses in your program of studies. Live and learn, and learn and live.

Things to think about

Make a table by ruling your paper into three columns. Head the columns as follows: MENTAL ATTITUDE, SAFE CONDITIONS, SKILLS. *In the correct column write the following words: avoid overexcitement, practice games, control temper, paint drawers white inside, fasten down rugs, whittle away from you, keep rested, put knives in holders, get help with worries, play off the street, drop the baseball bat, keep stairways clear, and be courteous.*

A review of the chapter

Many private individuals, scientists, medical schools, and other agencies carry on research upon health problems. They try to educate people to care for their health. Hospitals, clinics, public health departments, the government, and other agencies help to prevent or cure disease.

Bacteria, one-celled animals, and viruses cause catching diseases. Bacteria can be seen only by using a microscope. Disease germs may be spread by milk, water, and insects. The formation of good health habits is one means of protection against disease. The hands should be washed before handling food. The body has ways of protecting itself against disease germs. Quarantine is one way of preventing the spread of contagious diseases. Malaria and yellow fever are carried by mosquitoes. Flies may spread disease by carrying bacteria on their feet and bodies. Mosquitoes breed in water, and flies breed in filth.

Vaccination is an effective means of preventing smallpox. Diphtheria may be cured by using antitoxin, and can be prevented by inoculation with a mixture of toxin and antitoxin. Tuberculosis is a preventable disease and can be cured if treated in time.

Because milk is a good food for the growth of disease germs, it may be a means of spreading disease. Milk is made safe by pasteurizing it at a temperature of about 145 de-

Asahel Curtis photo

When the tide goes out, part of the ocean bottom is exposed. These men are gathering oysters from mud flats along the Pacific Ocean. Will it be safe to eat these oysters raw?

grees F. for 30 minutes. Milk may also be made safe by supervision and care of dairies. Sanitation is the name given to the science of keeping a community clean, and keeping its food and water supplies safe. State and city boards of health supervise water, milk, and food supplies. They take steps to prevent spread of catching disease.

Everyone can learn to live safely. Making surroundings safe, having a good mental attitude, knowing safety rules and practicing to develop skills will contribute to making one's life freer from accidents.

Word list for study

Be sure that you can pronounce, spell, define, and use in a sentence every word in this list. Each of these words has been defined or explained and used in this chapter.

pasteurize	germicide	research
hypothesis	fluorine	immune
bacteria	virus	culture
antiseptic	parasite	contagious
disease	isolation	carrier
inoculate	protozoa	DDT
X ray	vaccinate	antitoxin
	mental attitude	

An exercise in thinking

Below are two groups of sentences. The first group contains principles, which are large general ideas. Each sentence in the second group contains an idea related in some way to one of the principles in the first group. Write the numbers from 1 to 30 on a piece of paper or in your notebook. Find the principle which best explains the idea in the second list. Then after the number on your paper write the letters before the related principle.

List of principles

A. Many diseases are caused by bacteria, viruses, or animals that live in the human body.

B. Spread of disease may be prevented by destroying disease germs.

C. Spread of disease may be prevented by destroying or controlling carriers of germs.

D. Spread of disease may be prevented by making individuals immune to infection.

E. One can protect himself by avoiding contact with germs and by avoiding dangers.

F. The chief defenses of the human body against germs are the skin, the white corpuscles, and the antibodies or antitoxins.

List of related ideas

1. Germs rarely enter undamaged, healthy, skin.
2. A person should not drink from a public drinking cup.
3. Pasteurized milk is the safest kind of milk.
4. The white blood corpuscles attack disease germs.
5. Disease bacteria give off a harmful substance called toxin.
6. Danger of typhoid fever may be reduced by killing flies.
7. One of the best protections against disease is a healthy body.
8. Typhoid fever can be prevented by inoculation.
9. People with certain contagious diseases are quarantined.
10. Yellow fever can be controlled by fighting the mosquito.
11. Community garbage disposal plants help prevent the spread of porkworm.
12. Protozoa cause malaria.
13. Cattle may spread tuberculosis to people.
14. The human body has the power of making antitoxins.
15. Every fresh break in the skin should be painted with iodine.
16. A really clean tooth will not decay.
17. Sickness is sometimes caused by parasitic worms in the intestine.
18. Children should never make fires in playhouses.
19. Smallpox is best controlled by vaccination.
20. The best guarantee of clean food is strict government supervision.
21. The toxoid treatment prevents diphtheria.
22. Windows and doors should be screened to keep out flies.
23. We should wash our hands with soap before every meal.
24. Use of chlorine in the water supply is one way of preventing typhoid fever.
25. We should never kiss a sick person.
26. Tuberculosis is caused by a microscopic plant.
27. Wearing shoes is one means of

preventing the spread of the hookworm disease.

28. Porkworm and tapeworm can be killed by thorough cooking of meat.
29. Diphtheria can usually be cured by the antitoxin treatment, if it is given in the first stages of the disease.
30. Smallpox is caused by a virus.

Some things to explain

1. What are the diseases which we should never have?
2. What is the first thing to do when you are ill? What is the second most important?
3. In what ways can catching diseases be controlled better by the community than by the individual?
4. What is the difference in the way flies and mosquitoes carry disease?
5. Which do you consider the more dangerous insect, the fly or the mosquito? Give reasons for your answer.
6. Why should you never take patent medicines?

Some good books to read

Compton's Pictured Encyclopedia
Conn, H. W., *Bacteria, Yeasts, and Molds*
Crisp, K. B., *Health for You, Revised*
Eberle, I., *Modern Medical Discoveries*
Fishbein, M., *Common Ailments of Man*
Kallett, A. and Schlink, F. J., *100,000,000 Guinea Pigs*
Montgomery, E. R., *Story Behind Great Medical Discoveries*
Park, H. W. and Williams, A. W., *Who's Who Among the Microbes*
Silverman, M. M., *Magic in a Bottle*
Zinsner, H., *Rats, Lice, and History*

CHAPTER

4

Providing Pure Water

The problem of supplying pure water is perhaps the most important single responsibility of the community. No other source of germs can so quickly affect so many people as can impure water. Over a period of years, there were on the average 12 communities each year which had an epidemic caused by impure water. In one city 30 thousand people were made ill within a few days. The most common illness carried by impure water is so-called intestinal flu, which is a sickness accompanied by cramps, vomiting, and diarrhea. Adults rarely die of this disease, but babies sometimes do. Providing a supply of pure water for babies is especially important.

The problem of providing safe water is largely a problem of keeping water pure. To keep water pure, sewage must be treated in such a way that few bacteria escape into rivers and lakes from which people obtain drinking water. Yet most communities in the United States do not have really good sewage-disposal plants. Some of the largest cities in the United States still permit untreated sewage to flow into lakes, rivers, or the ocean. Only about one community in six, of the more than 30 thousand towns and cities in the United States, treats its sewage to prevent it from making water impure.

Can you see that having chromium plated faucets in your house may not guarantee you a drink of pure water?

Some activities to do

1. Visit your city water supply system. If possible go to the place where the water is obtained. Follow it through the purification plant, and learn about all the steps taken to make it pure. Learn where the pumping stations are located, and what kinds of pumps are used.

2. If your community has a sewage-disposal plant, visit it. If it does not have such a plant, try to learn why it has none.

Brown

There is plenty of water and ice in the world. Our problem is to find ways of making water available for our own use. Neither oceans nor icebergs can be delivered to our doors.

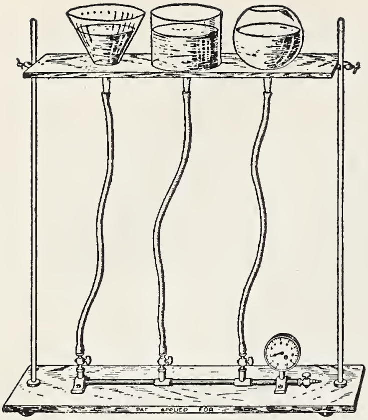
3. Obtain samples of commercial water softeners. Add the recommended amount to samples of fairly hard water, and test the resulting solution with soap, as explained in this chapter.

4. Obtain a gallon or more of some stagnant water from a pond. Examine it with a magnifying glass and with a microscope if one is available. Be sure that your sample contains many kinds of living things. Divide the water into two equal parts, putting the water into two large jars. The teacher may prepare some chlorine (danger—poison) by adding hydrochloric acid to manganese dioxide in a test tube equipped with a delivery tube, and bubbling the chlorine into one of the jars of water. This should be done only in a well-ventilated room, or under a chemical hood. Let the chlorine bubble into the water two or three minutes. Set both jars of water before a window, and observe them daily. In which do more living things survive? Use the microscope to check your observations.

5. Try dissolving in water various things you find around the house. Sugar, salt, soda, and other things may be tried. Test the water for hardness.

6. Learn where there is a building with a cooling system in your community. Arrange to visit it, and learn how the air conditioning unit operates.

7. Visit a plant where artificial ice is made. Observe what precautions are taken to keep the ice clean.



Standard Science Supply Company

With this equipment it is possible to show that only the depth determines the pressure of water. The pressure is the same when all three valves are opened as when just one is opened.

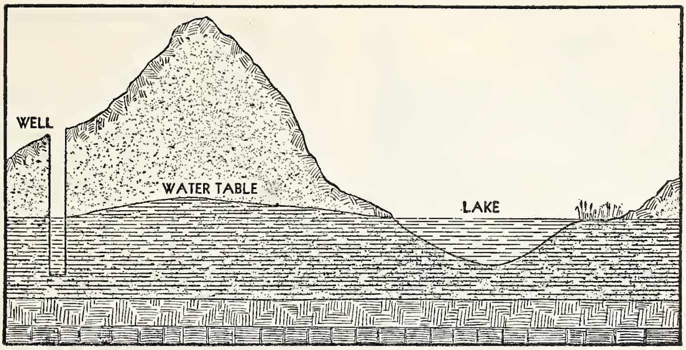
Some subjects for reports

1. Providing water for summer cottages
2. Special problems of providing water for villages
3. Your community water system
4. Your community sewage disposal system
5. How pressure is maintained in your city water system
6. Effect of providing pure water upon disease in your city
7. Epidemics caused by water-carried germs
8. Home water-softening equipment and its cost for operation
9. Farm water supplies and their purity in your area
10. Methods of saving water when supplies are scarce

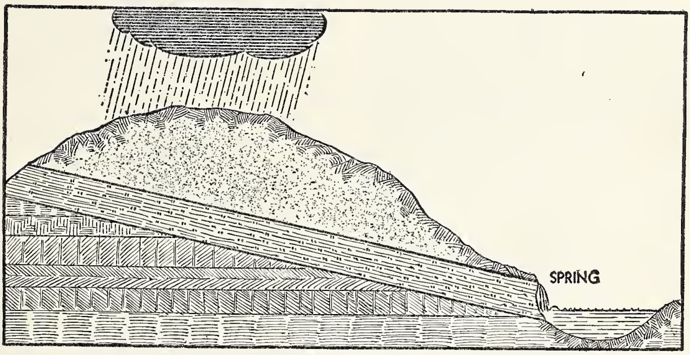
1. What are the sources of our water supply?

The problem of finding a supply of good water seems simple to those of us who have only to turn a faucet to obtain all the water we want. But to people who live in semidesert regions, the problem seems very difficult. In such places it is necessary to haul water in barrels from sources many miles away, and to use water sparingly. In very dry weather these distant sources may dry up, and water must then be hauled into the towns in railroad tank cars and sold by the gallon.

What is the source of water? Practically all the water which we use comes to us from the ocean as rain or snow. Of course such water is not salty, for the water in evaporating leaves the ocean salt behind. The amount of water in any region depends to a large extent upon the amount of rainfall. We may use rain water in several ways. In some places it is caught on roofs or flat areas and is run directly into tanks or cisterns. Usually, however, the water either runs off the ground into streams or soaks into the ground. Some water is stored in lakes for a time before it runs to the ocean.



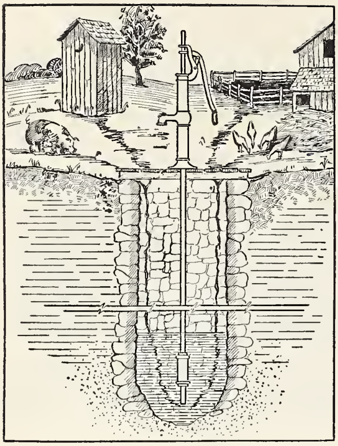
The top of the ground water is called the water table. When a well reaches the water table, it fills with water. The water table is found at the surface in lakes and swamps.



A spring occurs where ground water flows to the surface. A layer of rock which will not let water pass through, beneath saturated soil, provides conditions which make the spring possible.

Do we use surface water? Surface water is not commonly used directly for household purposes in its natural state. Although surface water usually is plentiful if obtained from a stream or lake, people rarely use it because it is usually impure.

There are two meanings of the word "pure" when it is applied to water. Chemically pure water is obtained by distillation, and contains no minerals or other materials. Pure drinking water may contain minerals and many other materials in small amounts, but is safe to drink because it does not cause sickness. Water from lakes and streams usually contains mud, bacteria, other living organisms, and various objectionable impurities. Surface water is used for drinking only in mountain regions where the



Surface water is rarely clean enough to drink. Water is not purified by passing through a few feet of filth-soaked soil. This well is about as badly located and constructed as possible.

source is clean and in cities which can afford to purify the water in treating plants.

What is ground water? Water that soaks into the ground and is held in the spaces between the particles of soil and rocks is called ground water. Ground water sometimes extends to the surface, where it may form swamps. Usually, however, the surface is dry, because water evaporates from it.

Water held underground seeps downward through porous soil until it comes to an unbroken layer of rock or clay soil through which it does not pass readily. There it is held. In the middle and eastern part of the United States the top of the supply of ground water usually is 10 to 50 feet underground. The top of the ground water can be located by drilling wells into the soil since water flows into the well as soon as the ground water supply is reached. If several wells are dug near each other, the level of the upper limit of the ground water is found. This upper limit is called the *water table.*

If the surface rocks are porous, water soaks into them. If they are nearly waterproof, little water soaks in. If layers of porous rock slope from a region of heavy rainfall or snowfall, they carry water beneath the ground for long distances. Such a situation exists in the Dakotas. Here surface rocks take in water from the rains and snow of the Rocky Mountains. It flows eastward to the dry plains states. Many deep wells reach down into this layer of rock from regions where the upper soil is so dry that no water can be obtained from it.

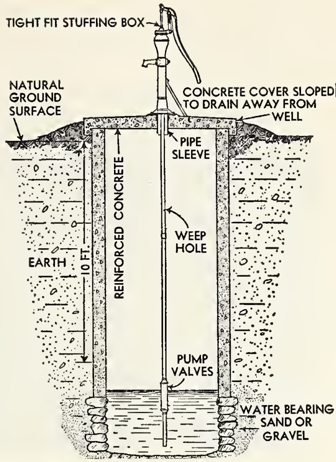
How can ground water be obtained? In some places the layers of rock carrying water come to the surface on the side of a hill so that the water can escape. If the water comes out of the ground slowly, it is called a seep. If it flows in a stream, it is a spring. Silver Springs in Florida is so large that the stream is navigable by small steamers from its source. There are many springs in other parts of the country that are used as sources of water by people living there.

Usually it is necessary to have a well which reaches to a point far below the water table. A well consists of a hole, dug by hand,

drilled, or driven into the ground, in which water may collect so that it can be drawn or pumped out for use. Except in large cities and dry regions, wells are most commonly used for water supply.

Shallow wells may be made by using ordinary digging tools or by driving a pipe fitted with a steel point deep enough to penetrate below the water table. Wells are dug only where they fill with water at a comparatively short distance below the ground. A driven well will provide water satisfactorily only if there is plenty of water where the point stops. The point usually has a metal strainer just above it to let in water and to keep out soil particles. Dug or driven wells usually can be pumped dry, and during a drought may stop filling completely.

Shallow wells are often polluted [made impure or unsafe] with local impurities, and generally they offer a limited and uncertain supply of water. To obtain a reliable source of water of high degree or purity, it is better to use deep wells. Since the water table may be below layers of hard rock, it is usually necessary to drill such wells. The drill consists of a long iron rod with a point of hard steel. Sometimes a point containing an industrial grade of diamonds is used to cut through the hardest rock. The drill may be rotated to cut a round hole in the rock, or it may be lifted and dropped upon the rock to break or wear it away.

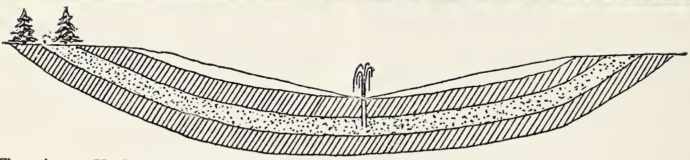


Construction of a good well requires thought and care. How many means of preventing impure water from seeping into this well can you find? What prevents water from freezing in the pump?

Wells may be drilled hundreds of feet deep before they reach an underground stream of water.

If the source of the water is much higher than the level at which the well is drilled, water may flow from the well from its own pressure. Such wells are called *artesian* wells. The term is also used to describe wells in which the water rises to a level much higher than the point which the drill had reached when the water first entered the well. In either case the pressure is developed for the same reason.

Is well water pure? Some well water may be so pure that it is almost like distilled water, while water from other wells may contain large amounts of dissolved



Top picture U. S. Geological Survey

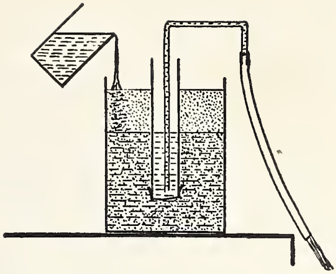
When the underground water supply is held under pressure between layers of rock, it may flow from wells without being pumped. In other deep wells the water may rise a considerable distance but not overflow. Both are called artesian wells.

minerals. This water may be called pure, however, if the dissolved materials do not make it unsafe for drinking. Water near the surface always contains traces of materials given off by living and decaying plants. Where farm animals are near, waste given off by the animals may seep into the well if it is poorly located or not carefully constructed at the top. Sometimes water seeps from outdoor toilets or from household waste thrown carelessly on the ground and fills the water supply with germs which cause disease. Water containing certain animal wastes is poisonous to small babies.

Water in deep wells is more likely to be pure. As the water runs through the ground, it is filtered or strained so that some of the impurities are left behind. Some of the germs die. However, even a deep well may not be safe, for the water may be made impure by seepage into the top of the well from the surface. If dirty water seeps into the layer of porous rock then the water from a deep well may not be pure. Geologists can usually tell where a well can be drilled to obtain pure water.

How are good wells built? A good well is dug or drilled where there is a supply of safe underground water. In general the ground surface should slope away from the well if it is located within 50 feet of a barn or other source of impurities. Even then it cannot be safe unless it is deep and protected by a proper cover and casing. The casing is the lining of the well. Surface drainage must be away from the top of the well.

The upper part of the well or spring should be lined with a wall of waterproof material. Either concrete or iron is satisfactory. The top cover of the well must also be waterproof. The top of the casing should be above the surface of the ground to prevent rain water and water dripping from the pump from running back into the well. The pump should be set into the well cover through an opening in which there is a pipe. The pipe should come up beneath the pump. The pump itself is often a source through which impure water enters the well. If there is an opening or slot where the rod enters the top of the pump, dirty water may get in. The practice of pouring water into the pump to wet the valves when the pump does not start is bad, since the water used may be impure. If the pump is well installed, the cylinder will be far enough down in the well that the valves will not dry out. A weep hole in the pipe permits water to drain from the pump and prevents freezing.



This diagram shows how to arrange the apparatus for the demonstration.

DEMONSTRATION: HOW DOES WATER FLOW INTO A WELL?

What to use: Large jar, lamp chimney, sand, cloth, rubber band, rubber tube.

What to do: Put about two inches of sand in the jar. Fasten the cloth tightly over the end of the lamp chimney with the rubber band. Put the covered end of the chimney in the center of the jar, resting on the sand, and fill the space around it with more sand. Pour water on the sand, until it is quite wet.

As the well, formed by the chimney, fills up, siphon out the water. To do this, fill the rubber tube with water, close both ends, and put one end in the water in the well, the other outside the jar, lower than the surface of the water, so that the water will run into the sink or pan.

Keep pouring more water on the sand, and see how fast water flows into the well.

What was observed: How long does it take water to seep through sand? Could you set up another experiment using clay instead of sand, and get the same results? What kind of pressure

forces the water to flow up the tube? What presses on the surface of the water? Does water run into the well as fast as it can be removed through the siphon? Explain your answer.

What was learned: Why does water enter a well? Can water be siphoned from a well?

Things to think about

Copy the following sentences in your notebook. Select the correct ending for each sentence.

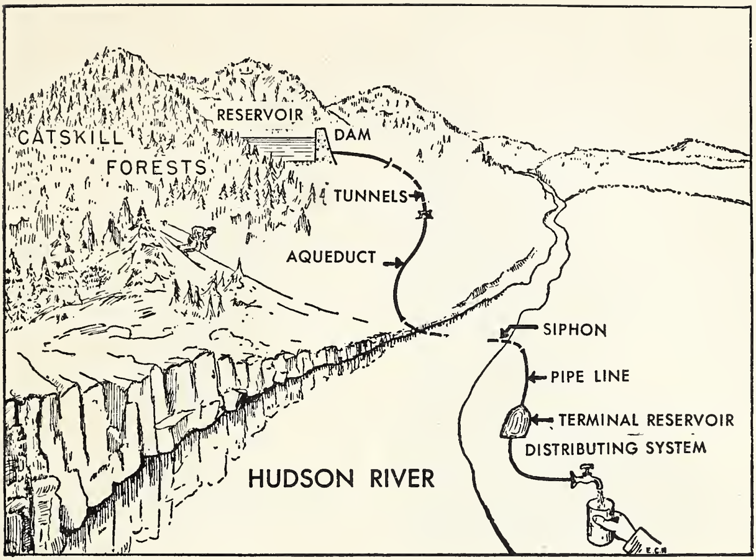
1. The level at which water will collect in a hole dug in the ground is at the (*a*) water table (*b*) surface (*c*) bottom of the underground stream.
2. When water flows naturally from underground, the flow of water is a (*a*) well (*b*) creek (*c*) spring.
3. Water runs underground best in (*a*) clay soil (*b*) sandy soil (*c*) solid rock.
4. A well made by forcing a pipe with a metal point into the soil is (*a*) dug (*b*) drilled (*c*) driven.
5. The deep wells are always (*a*) dug (*b*) drilled (*c*) driven.
6. The concrete cover of a well should be (*a*) on a mound (*b*) in a hollow (*c*) open so that the well can be seen.
7. In safe pumps the working parts are located (*a*) above the cover (*b*) in the well (*c*) wherever is most convenient.
8. Large cities usually obtain their water supply from (*a*) surface sources (*b*) underground sources (*c*) springs.
9. An artesian well is one (*a*) that flows (*b*) in which the water is stored under pressure (*c*) which must always be pumped.

2. Where do cities obtain water?

It was fairly easy for people of a small village to obtain a supply of water. But as the village grew, the supply of water was made impure by the presence of many people. Drawing water from many wells lowered the water table, and wells became dry. When the village became a city, a new supply of water became necessary.

Each city has its own problems, but there are three large sources of water supplies. There are several large lakes which contain enough water to be a dependable source. Chicago is the largest city that obtains its water from a lake. Most large cities obtain their water from rivers. Minneapolis and St. Louis take their water from the Mississippi. A few smaller cities must depend upon wells for water.

How does New York City obtain sufficient water? New York City requires over one billion gallons of water a day. This amount would mean, if each person used his share, that each New Yorker would receive about 130 gallons of water a day. Of course few individuals use this much water for drinking and household purposes. Large amounts of water are used in industry, in washing away sewage, and in protection against fire.

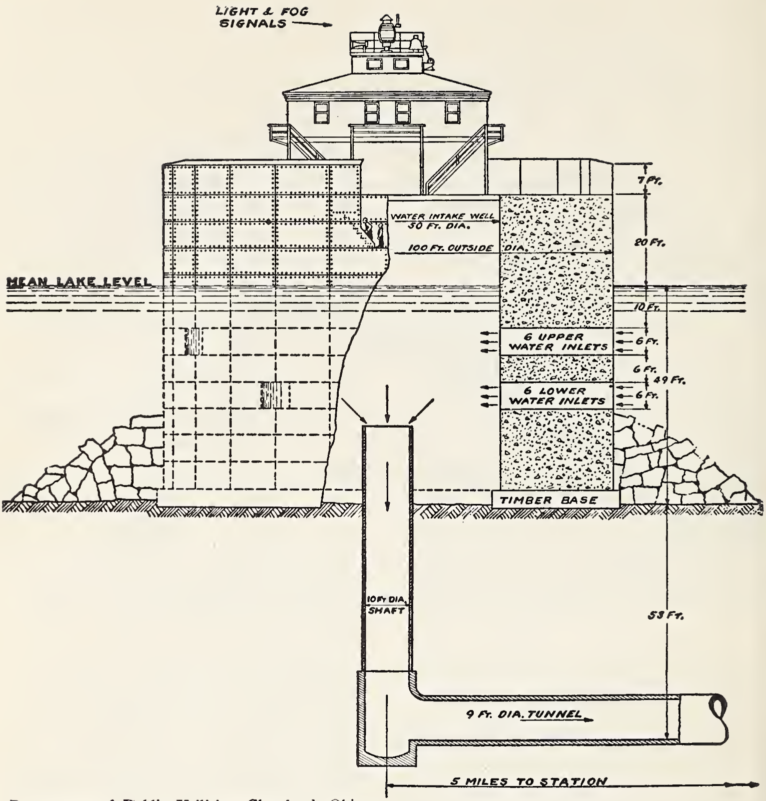


U. S. Forest Service

New York City obtains its water from a forested and protected watershed.

Since the lower Hudson River water is salty because of tides, it is necessary to find a source of fresh water outside of the city. In the Catskill Mountains, 125 miles north of the city, there is plenty of rainfall. Since there are few people living there, the water from the mountains is cleaner than runoff water from farm lands. Also, the forests of the mountains help to keep the supply of water more even than it is on bare land. For these reasons the Catskills provide a satisfactory source of supply. The water from the mountains runs off in small streams from an area of 314 square miles which the city controls. In this area are two large dams behind which water is stored. One of these dams is 220 feet high, and behind it there is a lake 12 miles long. The water in this lake, the Ashokan Reservoir, is 600 feet higher than the lowest point in New York City. Thus there is pressure to assure an adequate flow of water in the city if rainfall is normal.

How do mountain cities get their water? In the high mountains the problem of obtaining a water supply may be more difficult than one would expect. The amount of rainfall on the eastern side of the Rocky Mountains is small, since the moisture-laden winds come from the west. Denver is located on the east side of the Continental Divide, the name given to the ridge of mountains from one side of which water runs into the Pacific and



Department of Public Utilities, Cleveland, Ohio

The Great Lakes cities take their water from the lakes on which they are located. This crib is located five miles from the pumping station in the city of Cleveland. Cribs protect the water intake pipes from impurities and damage.

from the other side into the Atlantic. Since the country in which the city of Denver is located is one of the most mountainous regions in the United States, it has been necessary to bring the water from the west side over extremely rough ground to the east side. To solve this problem, engineers have constructed many miles of tunnels through the solid rock of the mountains.

Where do the Great Lakes cities obtain water? Chicago, Cleveland, and several other cities on the Great Lakes pump their water from the lakes. Cribs, or penlike buildings, are built out in the lake where the water is quite deep and likely to be more nearly pure and free of

dirt than is the water nearer shore. In some places they are located as far as five miles off shore. The crib is constructed of concrete and steel. In its walls are inlets located at intervals sufficiently high above the lake bottom to admit clear water. The pipe which carries the water to the city is located in the bottom of the crib as shown on the opposite page. Care is taken to prevent any kind of impure materials from entering the lake in the region of the cribs. The water which must be pumped from the cribs is nevertheless run through purification plants on the shore.

How do cities on rivers obtain their water? Except for the Great Lakes, the Mississippi River furnishes the largest and most even supply of water in the United States. Cities located along its banks pump water from the river. The water of the Mississippi River runs from thickly populated farming and city areas. It contains a great load of impurities. It also contains large amounts of minerals dissolved from the soil.

Cities using rivers as a source of supply have the hardest problem of filtering and purifying their water of any group in the United States. The inlet pipe located in the river must draw its water from cribs through the walls of which the water penetrates slowly to filter out the dirt and other suspended materials. In some cities the crib is a boxlike structure extending for several hundred feet up the river.

U. S. Bureau of Reclamation

Hoover Dam holds the waters of the Colorado River to form a lake 115 miles long. This dam is the highest in the world.

Some cribs are built of wooden planks, weighted to hold them in the river bottom. At other places they have been built of porous brick to last for a longer time. The amount of water which the city needs determines the length of the crib, although many cities have had to build additional cribs from time to time.

How is water obtained in the Southwest? Southern California is one of the most thickly settled parts of the whole country. Yet because of its location, it has very little rainfall over a large part of the year. Because of its climate, rich soil, and other advantages its population is still growing rap-

idly. Not only must the cities of southern California have large amounts of water for the use of the people and industry, but land must be irrigated everywhere if anything is to grow.

Water for the city of Los Angeles was obtained by the construction of dams to collect as much of the rainfall as possible during the brief rainy season. As the population grew, the city was forced to look for a larger and more permanent supply.

Four hundred miles east of Los Angeles is the Colorado River, the third largest drainage system in the United States. This river now provides water for the cities of southern California and other states of the Southwest. Across this river the United States Government has built Hoover Dam, one of the largest dams in the world. It is 727 feet above bedrock and forms a wall 950 feet long between the walls of the canyon in which the river runs. Behind it the Colorado River has carried water to form a lake 115 miles long. This water is elevated to a sufficient height to supply all the water needed for irrigation and use of the cities in this area. The amount used is equal to that required by New York, one billion gallons of water daily. This amount of water is enough to fill a lake two-thirds of a mile square 10 feet deep each day.

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

The two chief sources of water for cities are —1— water and —2— water. The first source is obtained from —3—, while the second source must always be obtained from —4—. New York City obtains its water from the —5— supply. The New York City supply is possible because of heavy —6— in these mountains. The most serious problem solved by Great Lakes cities is to obtain water free from —7—. A large part of the water used in the great Southwest must be obtained by use of —8—. Rainfall is heavier on the —9— side of the Continental Divide. Hoover Dam is located on the —10— River.

3. How is water delivered to cities?

The problem of finding a sufficient water supply is only part of the problem which cities have had to solve. In many cases it is more difficult to get the water from its source to the city than it is to prepare the supply. We have seen that New York, Denver, and Los Angeles located their water supply many miles from the city. To transport water for 400 miles, as Los Angeles does, is really one of the great engineering feats of all times. In only a few cases have the engineers been able to use the natural fall from a sufficiently

high elevation to conduct the water to its destination by gravity alone. The methods and devices used to carry water beyond serious obstructions are interesting.

How are aqueducts used? Aqueducts [ăk′wē·dŭkts] are huge pipes or channels used to carry water. They are built of various materials. Some of the oldest ones are built of stone, but the most recently constructed are made of concrete and steel. Some of the smaller ones are made of iron. They are welded or riveted to make them hold water. Sometimes seamless pipes which require welding at the joints only are used.

The aqueducts which carry water from Ashokan Dam to New York City vary in size from 11 to 17½ feet in diameter. The aqueduct used to carry water from Hoover Dam to the cities of southern California consists of a combination of concrete pipes and troughs. Wherever it was necessary to pump the water over obstructions, pipes were used. In other places, concrete-lined ditches could be used. As much cement was used in building of the Los Angeles aqueduct as would be needed to build a road 14 feet wide from New York to Los Angeles. The forms into which the concrete was poured were built of wood. The lumber used would have built houses for a city of several thousand people. Altogether the aqueduct cost almost 250 million dollars.

When are tunnels used? Sometimes the cost of constructing an aqueduct around a barrier, particularly if that barrier is a mountain, is much greater than can be justified by its use, and the expense of pumping large amounts of water over the obstruction is too great. In these cases it is better to use one or more tunnels.

A pipe is called a siphon when it dips into a low place and rises on the other side.

A tunnel is an underground tube, whereas an aqueduct is always placed on top of the ground. Often the work of digging a long tunnel through a mountain is started at opposite ends at the same time. Digging is done by

Denver Board of Water Commissioners

Many cities carry water through tunnels. This tunnel is in the process of construction. Notice that the steel rods are in place inside the tunnel. These were later covered with concrete.

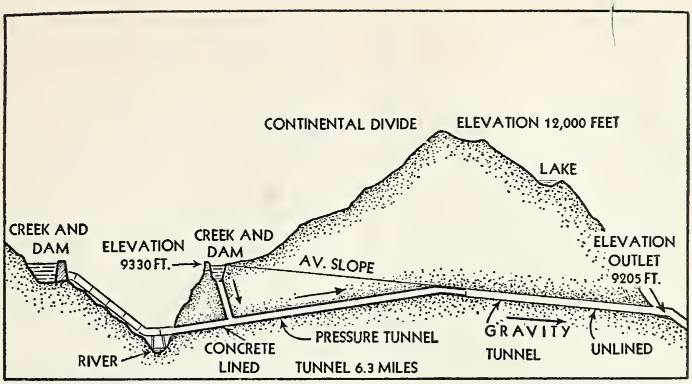
electrical machinery. Railroads are laid in the openings to haul away the rock and soil, and every device known is used to prevent the walls from caving in.

In digging a tunnel through the Coast Range of mountains to carry water from near Yosemite to the city of San Francisco, workers dug into poisonous gas underground and found quicksand in which heavy objects quickly sank from sight. In other places the earth settled so fast that the size of the tunnel became rapidly smaller. In spite of these difficulties, a tunnel 25 miles long was completed. While digging this tunnel, bones of ancient animals were found, some of which were 33,000,000 years old. Teeth of an ancient three-toed horse, the leg bones of an elephant, and the skull of a camel were found hundreds of feet below the surface of the mountains. Can you explain how they got there?

The walls of a tunnel are braced with wooden timbers to keep them from caving in as the tunnel is being dug. The timbers are used only temporarily, since most tunnels are lined with concrete. The thickness of the concrete depends upon the strength of the rock through which the tunnel is bored. If the rock is very solid and does not leak surface water or show other evidence of weakness, a thin layer of concrete is used to make the walls smooth. If the soil and rock are loose or full of water, concrete as thick as three or more feet must be applied.

One unusual use of the tunnel is to carry water for the city system under rivers. In the New York system such a tunnel is used under the Hudson River at Cornwall.

How is water pressure controlled? When water runs from a considerable elevation inside a closed pipe, the pressure may become so great that it will burst the pipes. Water 100 feet deep exerts a pressure of 43 pounds per inch at the bottom. The usual method of decreasing pressure is to construct reservoirs [rĕz′ẽr·vwôr, a storage tank] at



The Moffat Tunnel, which supplies Denver with a large part of its water, is one of the unusual systems in the United States. Note that it passes more than half a mile below the top of the Continental Divide.

intervals where the water surges out and releases its pressure. By means of a series of such artificial lakes it is possible to lower water from a considerable height. In flat countries, on the other hand, where there is not sufficient fall to keep the water moving, it is necessary to use pumps at frequent intervals to force the water along. Finally, at the city it may be necessary to pump the water into standpipes or water towers to provide enough pressure to force the water through the mains so that it can be distributed to houses at high levels or used in fighting fires.

The pressure of water depends upon its weight. A cubic foot of water weighs 62.4 pounds. That is, water a foot deep would exert a pressure of 62.4 pounds upon a square foot of surface. This pressure amounts to 0.43 pounds per square inch for each foot of depth (62.4 ÷ 144 square inches). A pressure of 30 pounds per square inch is sufficient on the lower floors of residences. This much pressure permits water to be used in garden hoses and for fire protection of houses not more than three stories high. If the pressure in the faucets is troublesome, it can be reduced by placing valves in the pipe. If the city maintains sufficient pressure in its mains only for the residences, it is necessary that special pumps be placed in the basements of tall buildings to provide a sufficient water supply in the upper stories. Usually a reserve supply is maintained by pumping water into a tank on the roof or top floor.

What are some parts of a city water system? Because it presents several unusual problems, the city water supply of Denver, Colorado, is an interesting one to show how different parts of a water system are fitted together. Denver is about a mile above sea level, and the two rivers from

which the water is obtained are about 4000 feet higher than the city and on the opposite side of the Continental Divide. At this point the Continental Divide has an elevation of about 12,000 feet. To get the water across the mountains it was necessary to construct a tunnel 6.3 miles in length. Water is led into the tunnel from creeks by canals, pipes, and a siphon. The water flows through the tunnel by gravity.

Another and older part of the water supply comes from various streams on the eastern side of the Continental Divide. In the older system there is a dam which forms a lake more than seven miles long in a mountain canyon. This lake stores water which may be used when there is little rainfall in the summer. Below this lake is another dam which forms a second reservoir. The lake behind this dam is filled from the old supply source when there is plenty of water during the rainy season. Aqueducts have been constructed to lead the water from all these sources to various storage reservoirs which are artificial lakes. The water stored in these lakes is then run by gravity to the purification plants.

How do the costs of city water compare? If there is an ample supply of fresh, clear water running through the city, water should cost very little. When it must be transported through aqueducts, tunnels, and siphons for great distances, the cost is considerably more. Water which is naturally soft and pure may be supplied more cheaply than water which needs much treatment.

The cost of water could be reduced in every city if not so much were wasted. The actual average need per person in a large city is probably not more than 75 gallons per day, but the people of many cities use almost twice this amount. A dripping faucet wastes in five days as much water as is needed for all purposes by one person for one day. A faucet which runs half open may waste in one day a month's supply of water for one person. And a faucet left wide open wastes enough water in a day for the use of an average family for one month.

You can keep down your own water bill and indirectly lower the cost of the entire water supply by replacing old washers with new, by turning off faucets when you are through with the water, and by care in many small ways. Do you turn on the faucet when you start to brush your teeth or leave the shower running while you prepare for your bath? Can you think of other ways in which water is wasted?

DEMONSTRATION: HOW IS WATER PRESSURE INCREASED?

What to use: Oblong naptha or varnish can with small screw-cap opening, nail, rubber stopper, tubing, air pump.

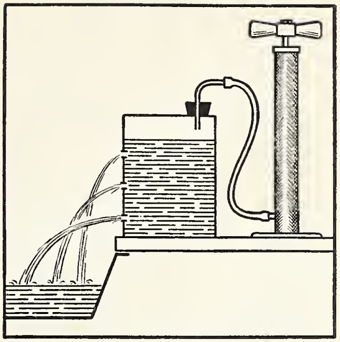
What to do: Make a hole in the side of the can near the bottom with a nail. Make other holes one-third of the way and two-thirds of the way up the can,

above and to the side of the first. Place it in the sink, and fill it with water. Observe how far water squirts from each hole.

Place a stopper in which a glass tube has been inserted tightly into the opening of the can. Attach the tube to the air pump by means of the rubber tubing, and pump air into the can as rapidly as possible.

What was observed: From which hole does water squirt farthest? Does the pressure seem to increase when air is pumped into the can? Which makes the most difference in this experiment, depth or air pressure?

What was learned: Answer the question at the beginning of the demonstration, explaining fully.



This diagram shows how to arrange the apparatus for the demonstration.

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

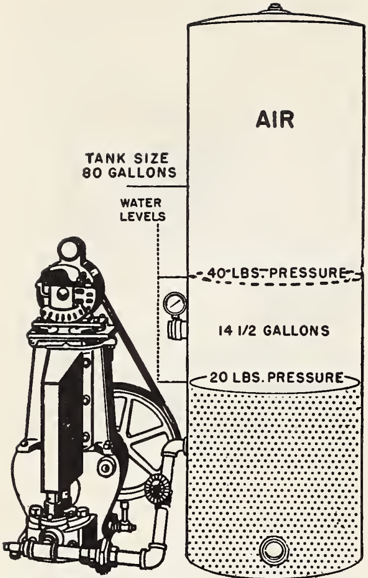
A large pipe through which water flows for city water is called —1—. The best aqueducts are made of —2—. Water is carried through mountains in —3—. Water pressure is increased by bringing it from a higher —4—, so that the depth of water in the pipes is —5—. For ordinary dwellings, a pressure of —6— pounds per square inch is sufficient.

4. How is city water purified?

No city has a water supply that is safe at all times. And the water available to many cities is so dirty that it is almost impossible to make it really safe. Cities along rivers dump sewage into the water, and cities downstream take this water into their water systems. Many of the lake cities drain sewage into the lakes from which they take their supply of water. Grease, human wastes, food particles, wastes from chemical, paper, and packing plants, and many other kinds of filth pollute river and lake water.

In an attempt to improve the purity of the supply of water, cities treat it in several ways. Impurities in water are of four general classes: mud, bacteria, organic [once living] matter, and dissolved minerals. Removal of the first three of these classes of material is called water purification. Removal of dissolved minerals is usually related to softening water.

How are solids removed from water? Mud and other solid particles in water are either heavier or lighter than water. If the water



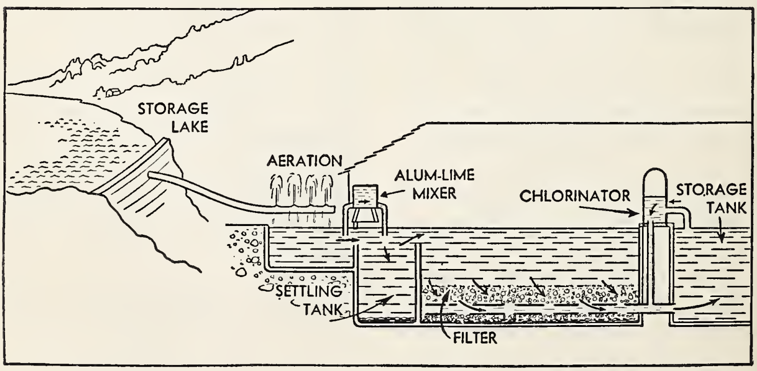
Deming Company

A home pressure tank depends upon compressed air to make the water flow. The force pump provides the pressure. Where is the outlet?

is allowed to stand for some time, the heavier particles tend to settle out, while the lighter particles float to the surface. Larger floating particles are removed by screens through which the water flows as it goes into the basins in which water is stored for purification. Sticks, leaves, paper, and the like collect on the screens.

The water first flows into tanks called settling basins, which are usually much like small lakes in appearance. A settling basin is generally lined with concrete. Mud gradually gathers on the bottom of the basin. As often as necessary the basin is drained, and the mud is scraped or washed off the bottom. If enough time is allowed, most solid impurities can be removed by settling.

To speed up the process of water purification, the water is commonly run through filters. A filter is a strainer composed of materials through which the water slowly passes. The slow sand filter is about 15 feet deep, and perhaps a block in area. In the bottom of the basin tile pipes are laid to draw off the water. Over these pipes is laid first a



The essential parts of a water-purification plant are shown in this diagram.

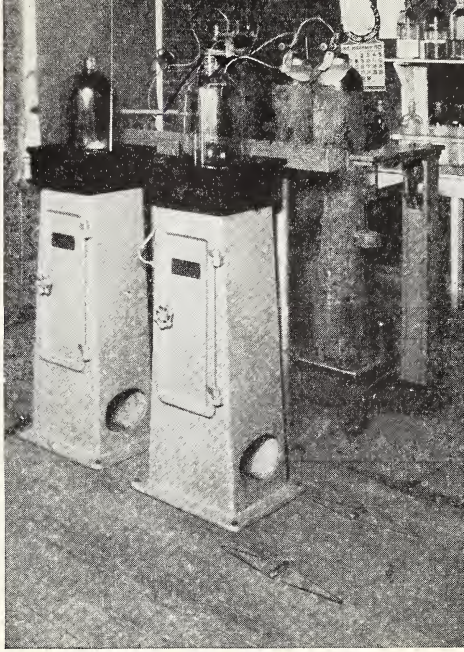
layer of broken rocks, then a layer of coarse sand, and finally two or three feet of pure filter sand. Filter sand may be obtained from ordinary bank or river sand by washing and screening. Pure sand may be obtained especially for this purpose. It must be of a certain graded size to work effectively.

The mechanical filter is smaller in size than the slow filter. It is filled with carbon instead of sand above the layer of stones or drainage pipes. The carbon may be charcoal, coke, or specially treated hard coal. Carbon has the ability to take in certain types of impurities that are not readily held by sand. It also separates out the impurities more rapidly than does sand.

Filters remove a variety of materials from water. While mud is the most noticeable of these materials, bacteria and organic matter are also removed to some extent.

To clean a filter, water is forced into the basin from the bottom. The water causes the impurities to float free of the filter materials, and carries them out to a waste pipe leading to a stream or lake. After washing the filter, the water which first flows through it is discarded until the filter materials have settled back into place, and are again performing their function.

How are organic impurities removed? Many organic materials are removed by filtration. Other materials are removed by the action of oxygen. To put the largest possible amount of oxygen into the water, it may be sprayed from nozzles [small openings] high into the air, to fall back into one of the purification basins. Although air may be added to water at almost any stage of the purification process, perhaps the best time is between settling and filtration.



Denver Board of Water Commissioners

Killing disease bacteria is the most important single process in purifying water. The chlorine which is used for this purpose flows from the steel cylinders into the chlorinators where it is mixed with water flowing to the storage tanks.

Organic matter in water gives it objectionable tastes and odors. Water of the upper Mississippi sometimes tastes "swampy" because of the number of plants

which grow in the swamps and lakes from which the river drains its water. Wastes from sewage and industrial plants may give water especially unpleasant tastes and odors. Microscopic green plants may grow in the water, even in the settling basins themselves, and give taste to the water.

Addition of oxygen to water is not an effective way of killing most germs.

How are bacteria removed from water? After water flows from the filters, there still remain in it many bacteria which were too small to be caught in the filter material. To kill these bacteria, chlorine [klō'rēn] is used. Chlorine, one of the elements, is a greenish-colored gas. In its pure state it is a deadly poison, but in the amounts used in city water it is entirely harmless to people and deadly to bacteria.

After the gas is run from a tank into the water, the water is allowed to stand for 24 hours to give the chlorine time to act to kill all the bacteria. Chlorine is slow in its action.

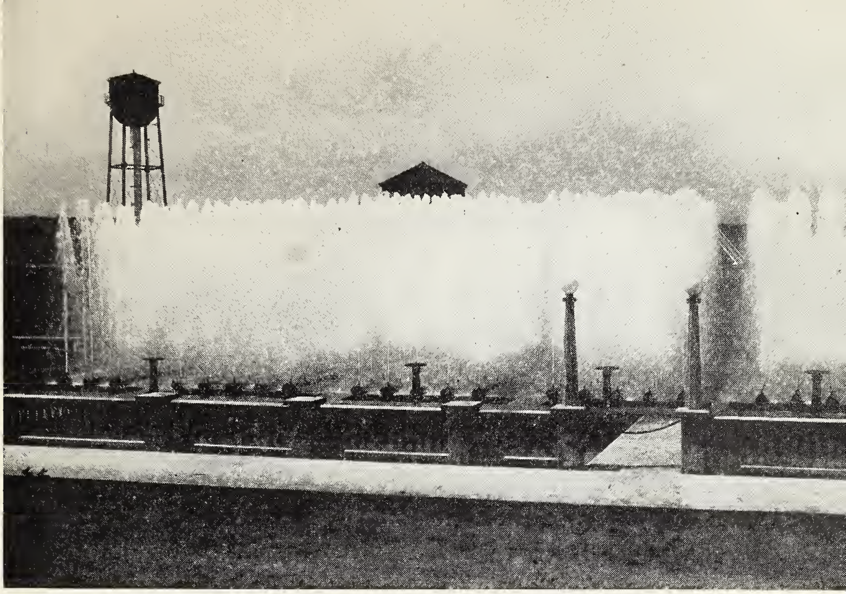
Chlorine will kill germs only in fairly clean water. If water contains lumps or even tiny particles of dirt some of the germs inside such lumps cannot be reached by the chlorine. However you can get particles of germ carrying material into your body when you drink the water. Some germs, including the one causing amoebic dysentery, are not killed by chlorine. Chlorine does not remove toxins and poisons given off by decay processes.

Why is water tested? It is extremely difficult to test water for disease germs. A given small sample might contain no germs, yet the water that a person would drink in a day might contain enough to make him ill. The harmless coli bacterium which lives in the human large intestine is so common in water that it can be used as an indication of how many germs water carries. Water is considered safe, according to standards of the United States Public Health Service, if it contains not more than five of these coli bacteria per pint. Water which enters many downriver city water plants contains several hundred thousand coli bacteria per pint. They are accompanied by unknown and uncounted other bacteria and germs.

Constant tests should be made. One error or breakdown in the purification process may make thousands of people ill. Careful testing may detect failures of the purification processes, and save lives.

How is water delivered to homes? Regardless of how efficient a city purification plant may be, its original cost and the expense of operation is completely wasted if the water system is not properly designed to keep out impurities after the water leaves the plant. Sometimes the water mains are leaky. If the ground water can seep [leak slowly] into a water pipe, the entire supply may be made unsafe.

There are various places in



Denver Board of Water Commissioners

When water is sprayed into the air, it absorbs oxygen which removes odors and some unpleasant tastes from the water. Otherwise aeration does little to purify water.

which contact of surface water with water of the city system can be made. For each house there is a cutoff valve at the street which can be closed to shut off the water supply. A pipe from this valve comes to the surface so that a long rod can be used to turn the valve. Ordinarily this pipe has a cover, but if the cover is removed for some reason, impure water may flood the cutoff.

Sometimes people draw water into open tanks directly from the city system. If the water in the tank becomes contaminated, it may back up in the mains and the water in the whole system will be made unsafe. In one city an epidemic of typhoid fever was traced to such an open tank.

Cities depending upon deep wells for their water supply have had the whole system contaminated [made unsafe] by failure to protect the casing during times of flood. In pumping stations the pumps have been located in pits in which water can collect and seep into the pumps. Thus dirt is actually pumped into the city mains. In one city an epidemic [a widespread disease] was traced to such a pit into which water leaked from a near-by sewer.

DEMONSTRATION: HOW IS MUDDY WATER PURIFIED BY FILTRATION?

What to use: Lamp chimney, cheesecloth or flannel, charcoal or hard coal charred, rubber band.

What to do: Fasten the cloth over the end of the lamp chimney. If cheesecloth is used, fold it to make several layers. Put about four inches of charcoal in the lamp chimney, and slowly pour the muddy water into the lamp chimney so as to disturb the charcoal as little as possible. If the water is not clear immediately, wash the filter material and try again.

What was observed: Does the water seem clearer after it passes through the filter? Where is the mud deposited? Why is charcoal a good filter material? How does the surface of charcoal compare with that of gravel?

What was learned: Answer the question at the beginning of the demonstration.

Things to think about

Match the following subjects and predicates. Copy the sentences in your notebook.

Subjects

1. Filtration
2. Testing water
3. Spraying water in the air
4. Chlorine
5. Natural filtration
6. Surface water
7. A slow filter
8. A mechanical filter

Predicates

A. purifies water in some deep wells.
B. is a process of removing dirt from water by straining it.
C. uses sand for filtration.
D. is gas which kills bacteria.
E. discovers errors in purification.
F. may contaminate water at pumps.
G. uses coal or carbon.
H. mixes oxygen into water to improve its taste.

5. How is water softened?

Water may be so completely free from bacteria that it is safe to drink and still be so impure that it cannot be used to satisfy many household and industrial needs. In this case the impurities are minerals dissolved as the water flows in streams or underground in contact with materials which it can dissolve. The objectionable minerals are ordinarily called lime.

Why is hard water undesirable? While these minerals do not do any harm in drinking water, they are an expensive nuisance in nearly all other uses of water. Some of the mineral deposits out of the water when it is heated. Teakettle scale is thus left behind when the water boils. Examine your teakettle at home. See if it contains any of this scale.

Other minerals do not precipitate [prê-sĭp′ĭ·tât, go out of solution] when the water is heated, but come out when brought into contact with soap. The resulting chemical forms a scum.

This scum is particularly bad when it settles out in the laundry. It makes clothes gray. Girls and

women have trouble in washing their hair with hard water, since application of the soap causes the formation of the scum on the hair. The scum is difficult to rinse off.

In large boilers used to generate steam the presence of these minerals is expensive The mineral tends to precipitate in the tubes of the boilers where the layers of lime formed prevents the water from heating. In order to produce the same amount of steam from hard water as from soft, more fuel must be used. The additional expense for fuel will nearly pay for putting in the equipment needed to remove the minerals before the water enters the boiler.

The presence of lime in the water used in batteries would very quickly spoil the battery. It is necessary for most garages and filling stations either to buy distilled water or to provide some means of preparing it.

In photographic work mineral impurities interfere with proper action of the chemicals used in developing. Also the coatings for films must be prepared in water free from certain minerals. Both private and industrial photography are bothered by these impurities in the water. In fact there is scarcely any phase of industrial work which would not be helped by the use of soft water.

How is water tested for hardness? The simplest way to test water for hardness is by the use of soap. Five drops of soap solution should be added to half a test tube of distilled water. After the water is vigorously shaken, the amount of suds formed is measured. This test tube is to be used for comparison. The water to be tested is treated in the same

Permutit Company

When a heating coil pipe becomes filled with mineral, the water can no longer cool the pipe, and the heat oxidizes and melts the metal, causing it to break. Hard water destroys heating equipment.

U. S. Geological Survey

Water is made hard by materials dissolved from the rocks. This river running from a limestone cave carries in solution the lime which it removed from the rocks.

way except that the soap solution is added to a half test tube, drop by drop, and shaken until an amount of suds equal to that on the first tube remains on top of the water. The degree of hardness can be expressed in terms of the amount of soap used.

Water taken from the upper Mississippi River requires 10 times as much soap to make the amount of suds that is produced by distilled water.

There are other more exact tests which chemists use, but this test is accurate enough for ordinary purposes and is easy to do.

What natural water is soft? There are a few springs from which soft water is obtained, but most ground and surface water contains substances dissolved from the soil. When water evaporates, the dissolved materials are left behind. The water which condenses from the vapor in the air is pure. Rain water is not chemically pure, however, since the raindrops dissolve gases of the air and may contain dust or soot, depending upon the nature of the air through which the rain is falling.

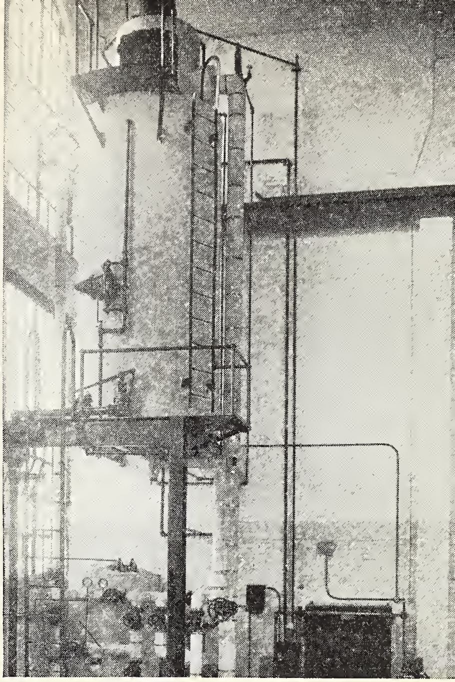
It is possible to obtain an adequate supply of soft rain water in any region in which the rain-

fall is fairly even throughout the year, where the air is free of soot or dust, and where the rain can be collected from a clean surface. Such conditions are common in the South and East, except in large cities. In the Middle West or West the air frequently contains too much dust to give a supply of pure rain water.

The best way to collect rain water is to put troughs along the eaves of the roof and connect these with pipes leading to a storage cistern. A good storage place for rain water consists of a cistern six or eight feet in diameter and about eight feet deep. Such cisterns are commonly built either of concrete or of brick with a waterproof coating of cement. To prevent the water from becoming dirty, the cistern should be closed, and provision should be made for throwing away the first water which runs from the roof since it will contain dust and soot which has gathered there. Cistern water should not be used for drinking or washing dishes until it has been boiled.

The island of Bermuda depends entirely upon rain water for its water supply, as its underground supply is salty.

How can water be softened for the home? To soften small amounts of water for immediate use, the chemical compound tetrasodium phosphate [fŏs′·fāt] is best. It can be bought for a few cents a pound at a drugstore. When added to the water, it forms a soft scale which does not stick and can be removed readily.



International Filter Company

Large water softeners are used in cities to soften water for the people's use. While soft water is not essential to health, it is much better than hard water because it is less irritating to the skin.

By using the soap test, you can find out for yourself the smallest amount necessary to add to a given amount of water to soften it until it will form suds when five drops of soap solution are added to a half test tube sample of the water.

Common washing soda is nearly as good as a water softener, but it should not be used in large amounts, since the chemical formed when it dissolves in water will weaken fabrics. Borax is

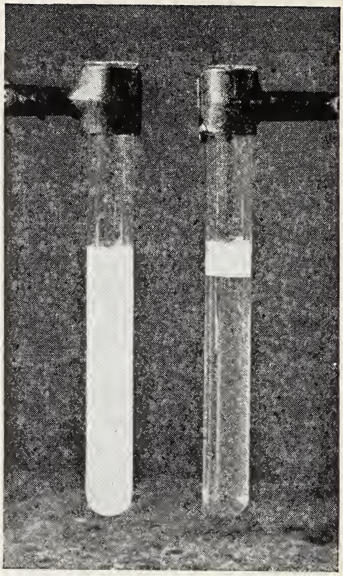
widely used but is not as good as either tetrasodium phosphate or washing soda.

Soap really softens water, since the first soap added to the water precipitates the lime. Until all of the lime is removed, no suds will form. Soap is an expensive water softener, though, because six times as much soap as washing soda is required to soften a given amount of water. Since washing soda costs one-fourth as much as good soap, it costs 24 times as much to use soap as it does to use a softener.

So-called hard-water soaps are usually much too strong to be used safely. They are also expensive. Borax and trisodium phosphate are often colored and perfumed and sold as bath salts. Their price has been increased from 10 to 20 times by fancy packaging and perfuming.

A mineral called *zeolite* [zē′ō·līt], or green sand, is particularly useful in water-softening tanks which can be attached to the plumbing in the house. The softener will continue to operate until all of the zeolite has been used. When the mineral is exhausted, it can be used again by running into the tank a solution of salt and water. The excess salt is then rinsed off and the softener is ready to operate. Such softeners are in many ways the best of all devices for softening water.

Are city water-softening plants practical? Although the cost of softening water is considerable, a city can save enough money by using soft water to pay for establishing a water-softening plant. These large water softeners, capable of softening the supply of water for an entire city, operate in about the same way as do the zeolite units for the home.



The tube on the right contains distilled water and five drops of soap solution. The hard water at the left contains 170 parts of lime in each million parts of water and 50 drops of soap solution. Note the appearance of each sample.

Water can be softened by distillation, since distilled water is not only soft but chemically pure. The amount of heat required to evaporate a small amount of water makes the process too expensive to be used for large water systems. On board ships, however, ocean water is distilled because it is cheaper to burn coal than it is to carry water.

DEMONSTRATION: WHAT MAKES WATER HARD?

What to use: Limewater, distilled water, tap water, test tubes, soap, Epsom salts if available.

What to do: Put five drops of soap solution into half a test tube of each kind of water. Observe what happens when each tube is shaken. Continue adding soap, counting the drops added to each solution, until a suds is formed on each tube. Make a solution of Epsom salts, if available, and test similarly.

What was observed: What forms in the limewater when soap is added? Is your city water soft or hard? How many drops of soap are required to make the hard water form suds when shaken?

What was learned: Answer the question at the beginning of the experiment.

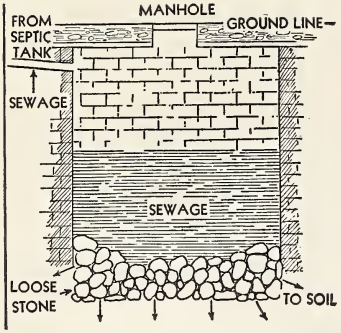
Things to think about

Copy the following sentences in your notebook. Select the correct ending for each sentence.

1. Water which contains minerals which form scum with soap is (*a*) hard (*b*) soft (*c*) impure.
2. To have something for comparison in testing hardness of water, we use in the control experiment (*a*) well water (*b*) soda water (*c*) distilled water.
3. Water is almost always softened in (*a*) packing plants (*b*) wash-racks for automobiles (*c*) laundries.
4. The natural form of soft water is (*a*) well water (*b*) rain water (*c*) river water.
5. The best water softener for small amounts is (*a*) tetra-sodium phosphate (*b*) borax (*c*) washing soda.
6. Water used in storage batteries is (*a*) distilled (*b*) softened (*c*) absorbed.
7. Teakettle scale is a result of (*a*) dirt in the water (*b*) too high temperatures (*c*) minerals dissolved in the water.
8. A cistern is a storage place for (*a*) sewage (*b*) rain water (*c*) city water.
9. Excess use of washing soda will (*a*) weaken fabrics (*b*) produce a scum (*c*) require more soap to make a suds.
10. Bath salts are often made from (*a*) soap chips (*b*) borax and trisodium phosphate (*c*) ordinary salt.

6. How do we dispose of sewage?

Proper disposal of sewage is essential if people are to keep well. We no longer dump slops from the windows into the streets, as did people in the middle ages. But in too many cities we do run untreated sewage into rivers, lakes, and the ocean. Too often our water supplies are unsafe, our beaches unclean, and our fish and wildlife supply greatly reduced by our poor methods of sewage disposal. Polluted water may even be used for irrigating vegetables, and may cause disease if the vegetables are eaten raw. We cannot feel safe from polluted water until every community and rural home has a safe sewage disposal system.



The absorption pit or cesspool is properly used in connection with a septic tank to increase the speed of absorption of liquids into the soil. Used alone it clogs and is unsafe.

What is sewage? Sewage from a house consists of wastes from the bathroom, kitchen, and laundry. It contains such things as soap scum, cloth fibers, vegetable material, grease, and coffee grounds. In cities material from packing plants, canneries, factories, garages, and the street may add to the sewage. Sewage consists largely of water, containing about one part solid materials to 1000 parts water. Sewage is found only where there is a water system.

Garbage consists of food waste and materials mixed into it. Garbage rarely contains many disease bacteria, while sewage usually does. Garbage is relatively solid, containing little water.

How do home sewage systems operate? In houses having running water there is a system of pipes, larger than the water pipes, through which sewage flows from the house. Whereas city water is under pressure, sewage is moved only by the force of gravity. Every pipe in a sewage system slopes downward. The pipes from the house may lead to a cesspool, a septic tank, or to sewage mains. Sewage mains carry sewage by gravity to disposal plants or streams.

A cesspool is perhaps better named an absorption pit, for it is designed to permit the water to be absorbed in the ground, while the solids are left behind. The pit is usually a hole about 6 feet across and 8 feet deep. It is lined with wood or concrete, and the bottom consists of loose stones between which liquids soak into the ground. Every few years the absorption tank must be cleaned out or filled up and a new one built. Unfilled and abandoned tanks are a serious source of danger, for they may cave in or young children may fall into them.

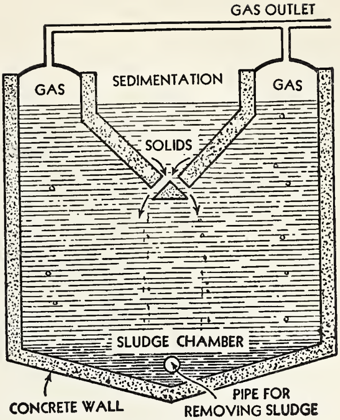
A septic tank operates on the principle that solids settle out of still water. There is first a compartment [a space divided off] into which the sewage flows, arranged to reduce the force of the moving water. The second compartment is the one in which solids settle. There usually is a third compartment from which the fluid is drained without disturbing the solids settled in the middle compartment, but this third compartment is not essential.

The solids in the septic tank are partially destroyed by the action of bacteria and settle out as a relatively harmless material

called sludge. Sludge is different from the materials from which it is formed. The liquids flow from the tank into a tile drain, and escape through the joints of the tile into the soil. If the soil is clay, it is best to surround the outlet tile with sand to make seepage possible.

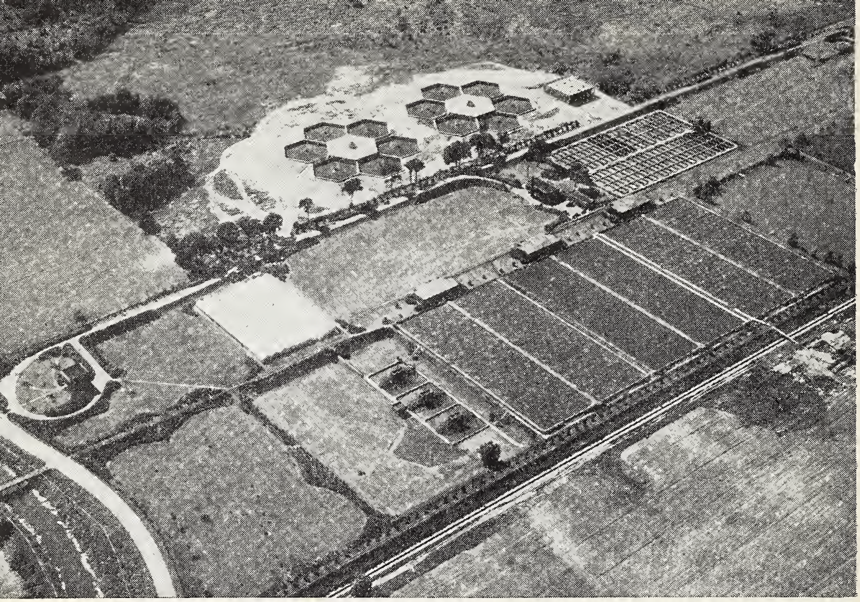
The solids must be removed from the septic tank when they are about a foot deep in the bottom of the tank. They may be spread on fields to dry and become part of the soil, or may be put into an absorption tank. The solids and fluids from a septic tank cannot safely be put on any field where vegetables are grown for human food. Use of untreated sewage as fertilizer is forbidden by law in some states.

How do cities dispose of sewage? The good city disposal plant is the same in principle as the home septic tank. The difference in the amount of sewage treated makes the problem of the city complex. The first problem is to separate the liquids from the solids. Floating solids are removed by screens made of bars. The sewage then flows into settling tanks, which may be ordinary open tanks; round, deep tanks; or other special shapes. One interesting settling tank, called the Imhoff tank, has a V-shaped trough running along its length at the top. The bottom of the V is open, which permits solids to settle into a lower compartment in which bacteria decompose [break down] the sewage to form sludge.



There are many kinds of settling tanks. One of the simpler is the Imhoff tank in which solids settle from a V-shaped trough into a much larger tank in which decomposition takes place.

All settling tanks are so constructed that the water moves through them slowly, and the solids settled to the bottom are not disturbed by the water running out. Sludge may be removed from the bottom of the settling tank by use of pumps, by scraping it into a trough from which it is washed into another tank, or by use of elevating machinery to lift it out. The sludge may be dried in a number of ways. In some plants it is spread on sand beds to permit water to drain out. In other systems it is passed over cloth strainers which permit the water to pass through as the dried sewage is scraped from the cloth into elevating machines. Sludge may be treated with steam to kill bacteria and sold as fertilizer. It may be burned in incinerators [ĭn·sĭn′ẽr·ā′tẽr, a fur-



Department of Public Utilities, Cleveland, Ohio

This air view of a sewage disposal plant shows the Imhoff tanks (*upper right*), the darker trickling filters (*right*), and the star-shaped sets of tanks for digestion of sludge (*top center*). The white-roofed buildings to the left are sludge drying beds.

nace for burning wastes]. Sludge may also be stored in tanks where the action of bacteria continues its decomposition.

The liquid sewage may be run into a stream as it comes from the settling tanks; it may be treated with chlorine to kill bacteria; or it may be sprayed over a broken stone filter where bacteria, worms, and molds act upon the many solids it contains to purify it further.

The worst method of sewage disposal is to run sewage into a small lake or stream. It is only slightly better to run sewage into a large river or into the ocean. In these methods the bacteria which cause decay are not given a chance to decrease the objectionable nature of the solids, nor is any action taken to destroy disease bacteria.

Rivers can purify themselves only if the load of waste is not too great. The action of oxygen and microscopic animals and plants, including decay bacteria, gradually oxidizes wastes. But when the waste load is too great another kind of bacterium which lives without oxygen takes over. Then the wastes, instead of being oxidized, are merely decomposed. They give off foul odors and produce slimes, toxins, and poisons. Wastes from industrial plants do not contain bacteria, but they do absorb oxygen as they decay. A

heavy load of industrial wastes may make it impossible for a river to purify itself.

How are wastes disposed of without use of water? About half the homes in the United States have no running water. Because many of these houses are far from other houses, their lack of sewage disposal plants is not as great a source of danger as might be feared. Yet there are dangers. Where the climate is warm enough for people to go barefoot, and in regions where people permit human wastes to be deposited on the ground, the hookworm disease makes many people ill. The hookworm eggs pass from the wastes into the soil, then into the bare feet, then through the blood stream into the intestines. There worms absorb food, give off poisons, injure the intestine, and weaken the victim. Proper disposal of wastes and the wearing of shoes will prevent this disease.

An outdoor toilet should have a deep pit lined with concrete to hold wastes. The pit should have a cover fitted tightly to prevent flies from entering. Chloride of lime may be thrown into the pit to reduce the odor and to kill bacteria.

A chemical toilet is so arranged that wastes fall into a tank in which lye or other chemicals are stored. The wastes are partly destroyed by the chemicals, and the remainder must be removed. Such chemical toilets are rarely completely satisfactory. They do not get rid of objectionable odors, and they require considerable attention. The lye, which destroys harmful bacteria rather thoroughly, is dangerous to handle. In general, the chemical toilet is not as satisfactory as the pit type.

How do we dispose of garbage? The best way to dispose of garbage in the country is to dig a trench into which is placed household waste. By having loose soil conveniently placed, the garbage can be covered immediately. When the trench fills up, another may be dug. Garbage decays in a year or two when properly buried.

Under no conditions should dishwater, garbage, and wash water be thrown on the ground near the kitchen door. There it may attract flies and make the yard unclean. Moreover, careless disposal of garbage and waste water may cause contamination of the well water.

In cities garbage is commonly stored in cans, from which it is collected into trucks. A garbage can should always be covered securely to prevent young children and stray dogs from scattering the garbage on the ground. Careless disposal of garbage attracts rats and flies which are carriers of several diseases.

A satisfactory garbage truck is covered with sliding panels which are kept constantly closed except at the time garbage is being thrown into the truck. The old-fashioned open garbage truck not only was unsightly, but menaced health by scattering garbage

along the streets. Garbage should be burned. Some cities treat garbage with steam to save the fats which it contains. Fats may be sold to make soap. A few cities dispose of garbage by feeding it to pigs, but this system is usually not satisfactory. Garbage is frequently not free from harmful bacteria. It also contains glass, metal, and paper—all of which are injurious to the pigs.

Dumping garbage near the city is an invitation to rats to move in, with the possible danger that they may spread disease and start an epidemic.

Grinding garbage and washing it away in the sink adds greatly to the work of purifying sewage.

Things to think about

Match the following subjects and predicates. Copy the sentences in your notebook.

Subjects

1. The heavy solid material
2. Gravity
3. A screen
4. The Imhoff tank
5. Many infections
6. The poorest sewage disposal system
7. Garbage
8. Sewage
9. Septic tanks
10. A cesspool

Predicates

A. is a huge septic tank.
B. settles in a settling tank.
C. is made of bars which remove floating wastes.
D. consists of wastes from houses, industrial plants, and streets.
E. is not a satisfactory way of disposing of wastes.
F. consists of running sewage into streams or lakes.
G. is the force which makes sewage flow.
H. is mostly household wastes.
I. require a good deal of care.
J. have been caused by polluted water at bathing beaches.

7. How is water used for cooling?

Since water absorbs large amounts of heat, it is the best common material to use for getting rid of heat that is not wanted. Because water which comes from deep wells is generally much cooler than the air during hot summer weather, cold well water can be used to cool buildings. Also, water freezes at a temperature sufficiently high to be readily changed to ice without costing too much money.

How is ice used in cooling? In order to freeze water, heat must be removed from it. Then the ice formed may be used for cooling, because it contains less heat than the materials to be cooled. People often mistakenly say that a substance absorbs cold. This cannot be true. What really happens is that the substance loses heat. The amount of heat which ice can absorb depends upon the difference in temperature between the substance to be cooled and the ice. Since ice freezes at 32 degrees Fahrenheit, it will remove heat from materials as long as there is any ice

left and their temperature is higher than that level.

The most common device which uses ice for cooling is a refrigerator. A compartment is provided in the upper part of the refrigerator in which a quantity of ice is placed. As air is cooled, it settles to the bottom of the refrigerator where it is warmed by the heat in the food. Once warmed, it rises to the top of the box where it is again cooled as it passes over the ice. Containers which would interfere with the circulation of the air should not be placed in the icebox.

Ice is also used in cooling railroad cars in which meat or other perishable materials are shipped. The ice compartments are located in both ends of the car, and the air circulates in the same way that it does in a household refrigerator.

How can a supply of ice be obtained? As ice freezes, some materials which may be dissolved or suspended in it are displaced, since the amount of space between the molecules is reduced as heat is removed. Consequently ice may be taken from rivers whose water would be unsafe to use for drinking purposes. This ice is still far from pure, although many dangerous bacteria are killed by freezing temperatures. Do not put river ice directly into drinks! A large amount of the ice used is obtained from rivers and lakes during the winter and stored in icehouses. It is prevented from

The neighborhood movie depends upon its cooling system to attract patrons in the hot weather. Since artesian wells provide cool water, they are frequently used as a source of water for cooling systems.

melting during hot weather by being packed in a considerable thickness of sawdust. As long as sawdust is dry, it is one of the best insulating [capable of stopping heat movement] materials.

Storing a supply of ice large enough for a city would require the construction of buildings of tremendous size. Fortunately a process of freezing ice as it is needed has been developed. City water is frozen in large tanks, many of which will hold as much as 300 pounds of ice. The tanks are surrounded by a salt solution [brine] cooled below 32 degrees F. Pipes containing expanding ammonia gas run through the brine. When ammonia is compressed, it loses heat and becomes liquid. The liquid ammonia is allowed to cool and is then conducted to the pipes in the brine. As the gas expands, it takes heat

Water splashing and dripping through this tower is cooled by the evaporation of water from the surface of the drops. This tower is located on an ice plant in California.

from the brine, which freezes the water in the tanks. Artificial ice is fairly pure and free from foreign particles.

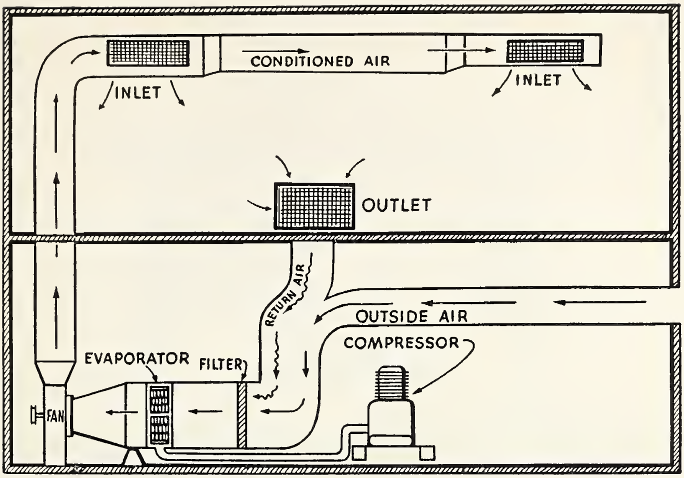
Artificial ice can be purchased for 40 to 60 cents a hundred pounds. This much ice will cool an average-size refrigerator for about three days during hot weather.

How is water used in air conditioning? Comfort depends upon having air in a room at the right temperature and humidity [condition of moistness]. If the air in a room is too moist, evaporation from the skin takes place slowly. If it is extremely dry, evaporation may be so rapid that one is actually chilled in a room that is quite warm. Also, air should be clean. If it contains pollen and other dust particles, it is bad for people who are sensitive to these things.

To maintain a more ideal condition of the air, many modern buildings are equipped with air-conditioning units. A system of pipes circulates air from the unit to the various rooms and back to the unit. The circulating system is very much like that used in heating with hot air. The air-conditioning unit itself consists of a box containing pipes, around which the air is blown by a large fan. Screens are used to filter out dust particles, and a spray of water serves to wash the air further as well as to provide it with the proper amount of moisture.

The air may be heated or cooled by the unit. To heat the air, hot water is run through the pipes built in the path of the circulating air.

During the summer it is desirable in many parts of the country to cool the air. It is accomplished in the air-conditioning unit by circulating cold water through the same pipes which are used for heating the air in the winter. After the water absorbs the heat from the air in the circulating pipes, it is run into either the sewer or storage tanks where it is used for the regular water supply. In large air-conditioning units, so much water must be used that often a supply well has to be drilled.



Some air conditioning is done by apparatus in the basement. The machinery is much like that in an electric refrigerator. The air is cooled at the evaporator, while the compressor supplies liquid to keep the evaporator cool.

Sometimes the heated water is cooled by spraying it into the air and catching the water which falls in a series of shallow trays. Since some of the water evaporates, the remaining water is left considerably cooler.

Small air-conditioning units for use in busses and railroad cars use the same water over and over again. The water is pumped through the coils outside of the car where it is cooled by the rapidly moving outside air. The cooled water returns to pipes inside the car. Inside air is circulated over this second set of pipes which carries the cooled water. If it is desired to cool a room more than can be done with water at its normal temperature, ordinary ice or dry ice [solid carbon dioxide] may be packed around coils of pipe through which the water passes before it is used to absorb the heat from the room. A room should be kept no cooler than 75 degrees F. in summer.

The thing to remember is that if the air in the room is to lose heat, the water must be at a lower temperature than the air. Some self-contained cooling units which have been offered by certain manufacturers to be used in cooling a single room are of no value unless they are so constructed that they can be attached to the water supply and sewer, or so built as to blow warm air out the window. A cooling unit which operates entirely within a room can do little more than circulate the air in the room, since heat absorbed as the air circulates over the pipes must be lost to the air in the room.

How can water vapor in the air be removed? In many parts of the country, summer air is very humid. When the air contains large amounts of water vapor, the rate of evaporation from the body is slow, and a room may seem warm even though the temperature is fairly low. To get rid of extra water vapor, air-conditioning units dry the air. Some are equipped with special types of filters containing chemicals which will absorb large quantities of water. As the air is blown through these filters, much of the moisture is removed.

Water vapor may be removed from the air by condensing it. To do this, the air is circulated around pipes containing cold water. Water collected on the pipes drips into a pan with a drain to the sewer.

Things to think about

Match the following subjects and predicates. Copy the sentences in your notebook.

Subjects

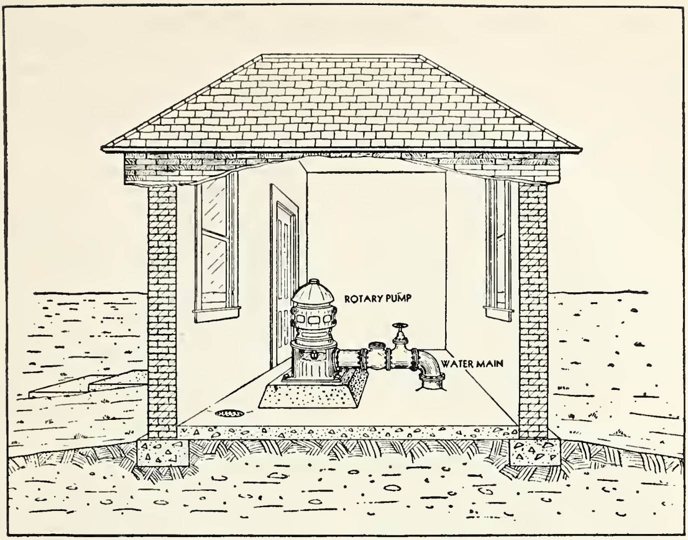
1. The cooling substance
2. A refrigerator
3. Sawdust
4. Circulation of air
5. Some of the dangerous bacteria in river water
6. Ammonia
7. Artificial ice
8. Body temperature
9. When the humidity is high, the air
10. Air-conditioning units

Predicates

A. is fairly pure and free from foreign particles.
B. is necessary for cooling foods in a refrigerator.
C. are destroyed by freezing.
D. is affected by evaporation of water from the skin.
E. circulate, cool, and clean air.
F. is used in making artificial ice.
G. absorbs heat from materials cooled.
H. is a common device which uses ice for cooling.
I. is one of the best insulating materials.
J. seems warmer than it really is.

A review of the chapter

Two sources of the community water supply are commonly used —surface water and ground water. Ground water is obtained by means of wells which are either dug, driven, or drilled. Large cities depend chiefly upon surface sources for their water, and in many cases have had to obtain it by expensive systems of aqueducts from sources several hundred miles away. Regardless of the source, water should be purified and regular tests made to see that its purity remains the same. Mineral impurities make the water hard and must be removed before it can be used for certain processes. The use of dependable



A properly located pumping plant is built above the level of the surrounding land. The building is of concrete and brick. At the top of the shaft is the electric motor. The pump, which is deep in the well, forces water into the main.

home water softeners is satisfactory for obtaining water for laundry and other washing purposes.

The sewage should be treated before it is allowed to mix with the water in rivers or lakes. No one is safe from disease as long as improper disposal of garbage and sewage continues in a community.

Because of the ability of water to absorb large amounts of heat, it is widely used in air conditioning.

Word list for study

Be sure that you can pronounce, spell, define, and use in a sentence every word in this list. Each of these words has been defined or explained and used in this chapter.

sewage	chlorine	hard water
surface water	ground water	water table
polluted	artesian	siphon
crib	aqueduct	tunnel
reservoir	settling basin	filter
coli bacterium	precipitate	sludge
cesspool	septic tank	decompose
garbage	humidity	

An exercise in thinking

Below are two groups of sentences. The first group contains principles, which are large general ideas. Each sentence in the second group contains an idea related in some way to one of the principles in the first group. Write the numbers from 1 to 30 on a piece of paper or in your notebook. Find the principle which best explains the idea in the second list. Then after the number on your paper write the letter before the related principle.

List of principles

A. The amount of available water in all sources of supply depends upon the rainfall.

B. The earth almost always contains a supply of ground water.

C. Water dissolves minerals from the soil.

D. When water is quiet, undissolved solids will settle to the bottom.

E. A filter strains solids from water passing through it.

F. Before the water is safe to use, it must contain no harmful living bacteria.

G. Pressure of water is in proportion to its depth.

H. Most decomposition of sewage is caused by bacteria.

I. Water absorbs a large amount of heat per unit of weight.

List of related ideas

1. Most city water is run through a bed of sand or coal.
2. Water running from lakes is generally clear.
3. An overload of waste in a river causes sewage to decompose instead of to oxidize.
4. Water in an 80-foot standpipe has a pressure of about 35 pounds per square inch.
5. Chlorine is generally added to city water.
6. Sewage is purified to a small extent in the septic tank.
7. Water running over limestone is usually hard.
8. Water can be obtained by digging a well.
9. Water is stored in standpipes in most city systems.
10. Water given to babies should always be boiled.
11. A shallow well in a desert produces no water.
12. The first step in water purification usually is settling.
13. Well water frequently is hard.
14. When water is carried down mountains, it is necessary to let it run into lakes to avoid bursting the pipes.
15. A deep well in a desert may supply water.
16. Artesian wells contain water under pressure.
17. Sewage is sometimes sprayed over broken rock.
18. Water may be made safe to drink by putting chlorine in it.
19. A hot water bottle holds heat longer than an iron.
20. Bacteriologists test water to be sure it will not cause disease.
21. Hard water does not form suds readily when mixed with soap.
22. Typhoid is the worst disease commonly carried by water.
23. Hard water fills pipes with rocklike materials.
24. Cesspools used alone do not digest sewage.
25. Sludge is formed when bacteria act on sewage.
26. Many minerals in the soil are dissolved in water.

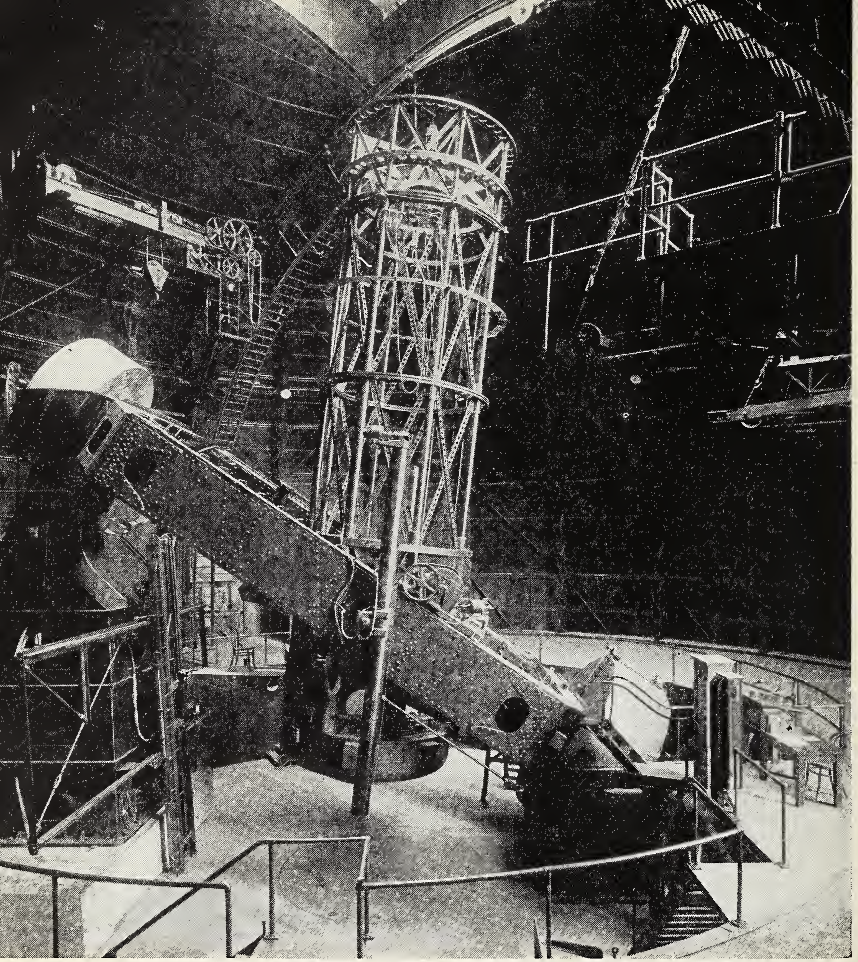
27. The lake behind Hoover Dam will eventually fill up with mud.
28. Water is cooled as it drips through a tower.
29. Water usually runs by gravity from storage lakes.
30. When water runs for long distances through soil, it may be purified.

Some things to explain

1. Why is it dangerous to go into a theater cooled to 68 degrees on a hot summer day?
2. Why was it safe for Daniel Boone to drink river water?
3. What danger may come from untreated water?
4. Why are bacteria useful in helping to provide a supply of pure water?
5. What is the advantage of locating a city near a mountainous region?
6. Why is it dangerous to believe that water purifies itself under natural conditions?

Some good books to read

Coyle, D. C., *Land of Hope*
Fisher, I. and Emerson, H., *How to Live*
Granick, H., *Underneath New York*
LeMay, G., *Story of a Dam*
Meister, M., *Water and Air*
Pigman, A. P., *Story of Water*
Pryor, W. C. and Pryor, H. S., *Water—Waste or Wealth*
Whitman, W. G., *Household Physics*



Mt. Wilson Observatory

UNIT THREE

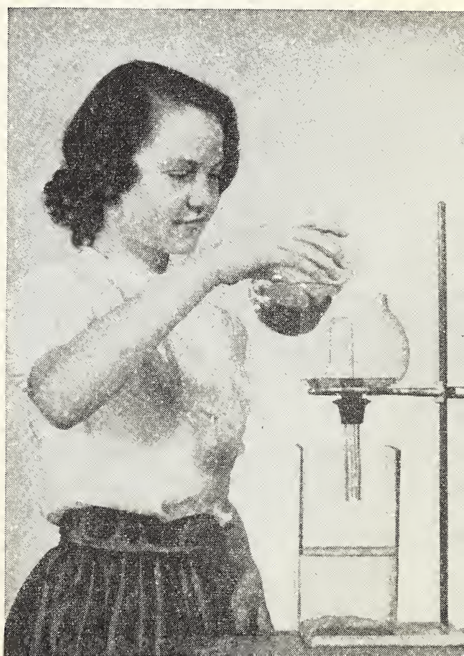
OUR PLANET THE EARTH

Nancy had the top of her mother's coffee-maker set up on a stand on the demonstration table. The children wondered what a coffee-maker could have to do with the study of the earth.

Nancy soon explained. She said, "When we were on a trip last summer we saw a sign which said *Boiling Springs*. We drove to the springs. They were not really boiling. Instead they were quiet for a while, and then all at once the water would surge and flow upward with considerable force. Except for the lack of steam, this bubbling did look somewhat like boiling. I wondered what caused a spring to flow in this strange way, and I did some studying. This experiment will show you the principle of the spring."

She picked up a stopper with a J-shaped tube in it. She put the stopper into the tube of the coffee-maker top so that the J was upside down, with the curve in the coffee-maker top. Then she put a jar beneath the tube, and poured water into the coffee-maker. When the water covered the top of the J-shaped tube, it began to siphon out of the coffee-maker. It continued until the short end of the J-tube was uncovered. Nancy poured more water into the coffee-maker, and again the water siphoned out.

She said, "Where there is a spring like the one I saw, there must be a sort of underground cave in which water collects. with an outlet which curves upward, and then down, like this J-tube. When the cave fills with enough water, it siphons out. When the cave is emptied so that the end of the outlet is uncovered, the flow stops. Then water seeps into the cave again, and the whole process is repeated. The reason the water seemed to boil in the pool was that the water from the cave flowed into the pool of the spring at the bottom. It was really just surging up."



CHAPTER

5

Our Earth in the Solar System

When you think about the many bodies which you can see in the night sky, you perhaps wonder if some other boy or girl is looking at the earth from another body in space. You may wonder if there are more interesting places in the universe than the earth. Ancient people had these same thoughts, and peopled the sky and space with imaginary beings.

Ancient people particularly noticed the bright objects which seemed to move around among the other stars. One of these, a bright, fast-moving object, was named Mercury in honor of the messenger of the ancient Greek gods. They gave these fast-moving objects in the sky the name of planets. The word planet comes from a Greek word meaning "wanderer."

With the discovery of the telescope, more exact information concerning these wanderers of the sky was obtained than ancient people had. It was then shown that the planets follow fixed paths in their movements around the sun. The revolution of the moon about the earth was recognized by early thinkers, but that other planets had similar moons was not known until Galileo discovered four of the nine moons of Jupiter. Since then, moons have been discovered around six of the planets, and minor planets in the region beyond the orbit [ôr′bĭt, path of a body through space] of the planet Mars have been identified. The discovery that the planets, together with their moons and certain additional bodies, move around the sun has made it possible for us to understand better the place of the earth among the stars. We know that the sun is the center of a system whose members move in definite paths about it. All these objects together make up the solar [sō′lẽr, of the sun] system.

Some activities to do

1. Obtain an up-to-date sky chart and locate the planets now visible.

Check their positions at a definite hour, and one week and two weeks later check them again. The best way to mark their positions is by their relation to the stars.

2. Obtain a field glass or, better yet, a small telescope and observe the moon. Locate the larger flat areas and craters. If you refer to a map of the moon you can learn the names of some of the most noticeable features you can see.

3. Learn when the next eclipse or partial eclipse will come. Be prepared to make observations when it occurs. If you will have a cardboard ready, with a hole in it about a quarter of an inch across, you can let the sunlight shine through it onto the floor. You will be surprised to find that you obtain a round image when the sun is not in eclipse, and a crescent-shaped image during the eclipse.

4. Look at the sun through heavily smoked glass and locate some sunspots. The glass must be so dark that the sun looks dim and red in order to look through it safely.

5. Make a chart to show the relative size of the planets. Make it large enough to display on the bulletin board.

6. Obtain a spring balance and a weight. In a safe place, where the weight will do no harm if it flies off the hook, swing the weight in circles so rapidly that it stretches the spring. Can you estimate the amount of added pull on the balance caused by swinging the weight. (If you tie the weight to the hook with a string, it will be less likely to fly off.)

7. If a rotator and steel hoop are available, rotate the hoop and notice how much it is flattened.

These images of the sun in eclipse were projected through tiny openings at the side of a Venetian blind upon the floor. Why are they crescent-shaped?

8. Lay an inflated football on its side, with the laces up, on a flat surface. Spin it as fast as you can. Explain why it stands on end.

Some subjects for reports

1. Some superstitious beliefs regarding the stars and planets

2. Hypotheses about the formation of the earth

3. The possible effect of sunspots on human affairs

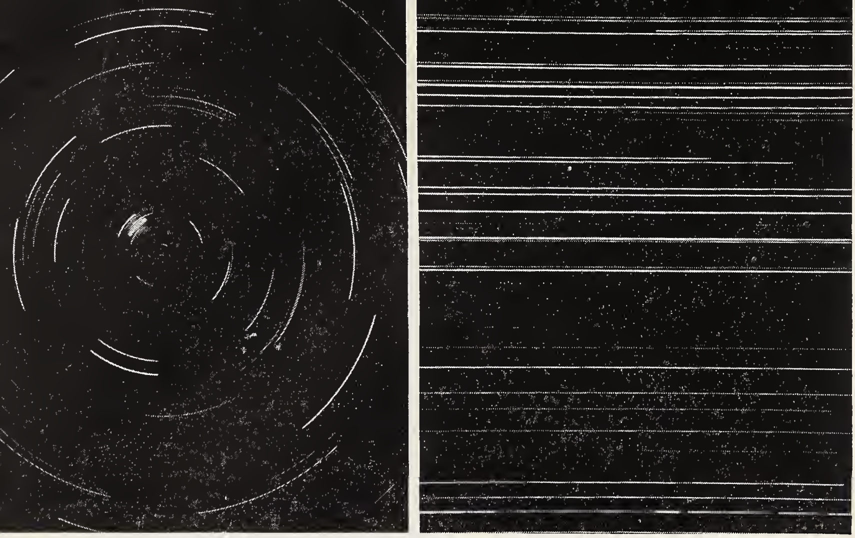
4. How Copernicus explained the solar system

5. The life and discoveries of Herschel

6. The asteroids and planetoids

7. The extremes of tides high and low

8. The surface of the moon



Yerkes Observatory

When a camera is pointed upward, the rotation of the earth causes stars to leave trails of light. Around the poles the trails are circular, and at the equator they are straight. The clearness of the trails depends upon the brightness of the star.

1. What are some objects in space?

Our ideas regarding our surroundings are continually being changed as new facts are discovered. This truth is especially well demonstrated when we consider the changes that have occurred in man's beliefs about the heavenly bodies. Without detailed knowledge, it was natural to explain astronomy in terms of the way things seem to be. Since all heavenly bodies appeared alike in some respects, men believed that they were all stars. And the fact that the stars were not exactly alike gave rise to many explanations which we know today are false.

Why are some stars brighter than others? To the human eye, stars seem to be about the same size, while the sun and moon appear to be much larger. In truth, many of the stars are larger than our sun and appear to be small only because of their great distance.

The stars vary in brightness either because they are nearer to or farther from us or because they vary in size or in temperature. A star that is large, near, and hot appears very bright indeed. Sirius [sĭr′ĭ·*ŭ*s], the dog star, is only slightly larger than our sun but is quite close and very hot. It appears as the brightest star in the sky. The star Vega [vē′g*ȧ*], in the constellation the Harp, is more than three times as far away as Sirius, but because it is very hot, it appears to be

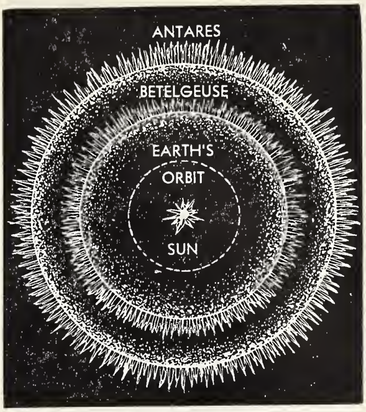
quite bright. Capella [kȧ·pĕl′ȧ], in the constellation Auriga [ô·rī′gȧ], is another bright star which is commonly seen.

Rigel [rī′jĕl], in the constellation Orion, is 540 light-years from the earth, but because it is very large and very hot, it appears to be brighter than most of the stars. Because it is so big and bright, it is called a supergiant. In the same constellation the star Betelgeuse [bē′t'l·jōōz], is only 270 light-years away, and while not as hot as Rigel, appears to be nearly as bright. This is because it is an extremely large star.

The stars are grouped together in the order of their brightness. Those of about the same brightness are said to be of the same *magnitude*. The brighter stars are of the first magnitude, while the faintest stars that can be seen on clear nights with the unaided eye are of the sixth magnitude.

Some stars are brighter at times than at other times. Astronomers do not know exactly why these stars vary in brightness.

The nearer planets are of about the same magnitude as the brightest stars, although Venus often appears brighter than any other object in the sky excepting the sun and moon. Venus sometimes can be seen in the daytime. The nearer planets also appear to be about the same size as the brightest stars. Some of them are called "evening stars" and "morning stars." The light given off by a planet is really reflected sunlight, while that given off by a star originates with the star.

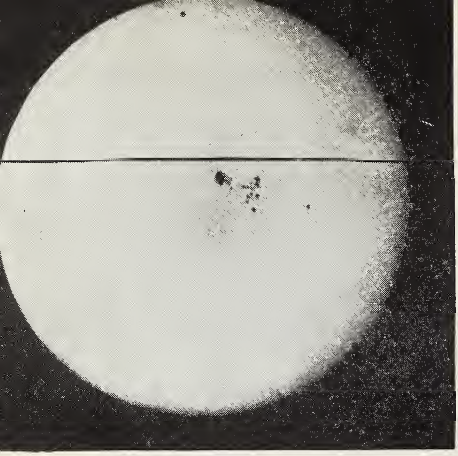


To compare the size of the largest known stars with that of the solar system, two have been drawn on the same scale as the distance from the earth to the sun, which is 93 million miles. Betelgeuse changes in size, sometimes becoming even larger than Antares.

Through a telescope the planets appear to be round objects like our moon, while the stars are not enlarged even in the biggest telescopes.

Are bodies in the sky much alike? Although the sun and moon look about the same size, the sun is very much larger. The moon looks about as large as the sun because it is nearer to the earth. Really the diameter of the sun is about 400 times as great as that of the moon.

The stars vary greatly in size. Some are about the same size as our sun, while others are much larger. If the star Antares could be placed in the position of our sun, the paths of the first four planets, which would include the



Yerkes Observatory

Because the planet Mercury is between us and the sun, it sometimes passes across the sun's disk as a tiny black speck. Its path is indicated by the arrows. What are the black spots on the sun?

earth, would be within the body of the star. It is only because it is so far away that it appears to be smaller than the sun. Just as the moon appears to be about the same size as the sun, planets seem to be as large as stars. The planets appear large only because they are closer than the stars.

If one compares the different stars, the brighter ones seem to be about the same distance away. Certain stars also appear to be very close together. Two stars which are seen close together only appear that way because they are nearly in the same line, just as street lights may appear close together when viewed from the end of the street. In reality the farthest star may be thousands of times as far away from us as the nearest star.

Most stars are so far away that they cannot be seen with the unaided eye. Thus familiar figures made by the stars would be difficult to see if all of the stars in the background were also visible.

What paths do the planets follow? When we learn that the sun, as one of the stars, is really the center about which the earth revolves, we can understand better the movement of the planets. They travel in fairly regular paths about the sun. If you will draw a circle on a piece of paper and place a marble in its center to represent the sun, the circle would almost represent the path which the earth follows as it moves around the sun, and the paper would be the plane of its revolution. The plane of revolution of the other planets is approximately the same as that of the earth. Consequently, there are times when the planets are in opposite sides of the circle about the sun from the earth and cannot be seen.

You can chart the path of a planet for yourself. Locate one of the planets as soon as it is dark, and draw a square on a piece of paper to represent the section of the sky in which you saw it. Mark the position of the planet and of a few large stars within the square. Each succeeding night when the stars are approximately in the same position as you located them in the square, observe the position of the planet. After you have repeated these observations, you can draw a line which will indicate the path and direc-

tions of motion of the planet. The first men who studied the motions of the planets had no telescopes for observing the skies but depended upon simple observation.

If you were to study one of these planets long enough, you would finally discover that it travels in an almost circular orbit.

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

The earth revolves around the —1—. The planets revolve around the —2—. The stars are not part of the —3—. The stars vary in —4— because they are not all the same distance away. The brightness of a star is its —5—. The moon is about —6— as large as the sun. The stars seem to form patterns called —7—. The brightest planet is —8—. The position of the —9— in the sky does not change rapidly. Planets seem to be about the same size as the stars because they are **—10—.**

2. What are the planets?

Since the planets are not stars but receive their light from the sun just as the earth does, they have day and night. However, their days and nights vary greatly in length from those on the earth. If the planet rotates more slowly on its axis than does the earth, its day is longer. If it spins more rapidly, its day is shorter.

Our year is based on the time that the earth requires to make one complete revolution about the sun. A planet also has years, but its year is not the same length as ours.

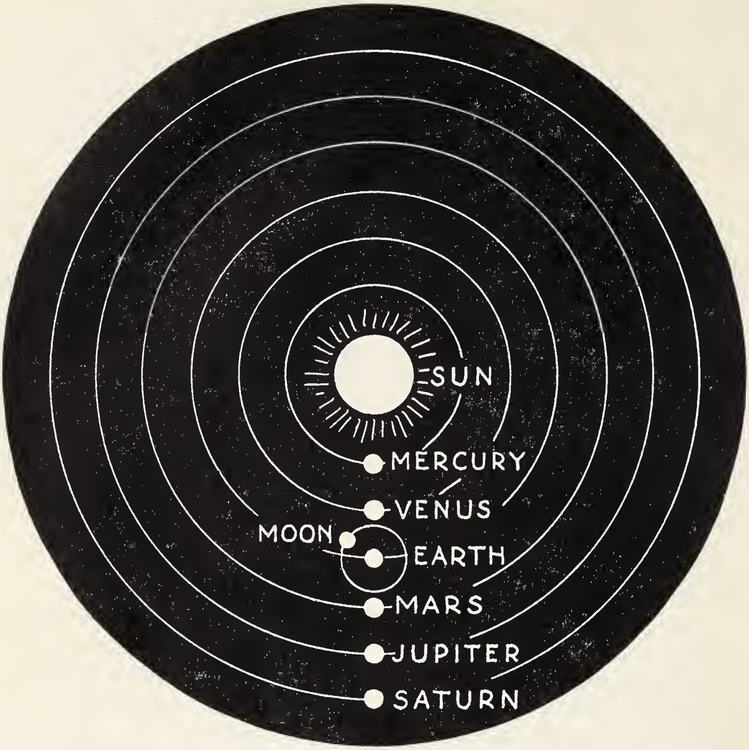
Planets vary in their distance from the sun and therefore receive greater or smaller amounts of heat. The possibility that there may be life on the other planets depends to a large degree on the amount of heat which the planet receives.

How many planets are there? Only five planets besides the earth were known to the ancients. These were named Mercury, Venus, Mars, Jupiter, and Saturn. They, together with the sun and moon, are our nearest neighbors in space.

As the telescope became perfected, additional members of the solar system were discovered. Galileo's discovery of the moons of Jupiter suggested to later observers that there might be other bodies among the system of planets. Since then three additional planets have been discovered. They are Uranus [ū′rȧ·nŭs], Neptune, and Pluto. These, together with the earth, make a total of nine.

Altogether 28 moons have been discovered and, in addition to these, certain small bodies known as asteroids [ăs′tẽr·oidz], or minor planets, have been dis-

3.

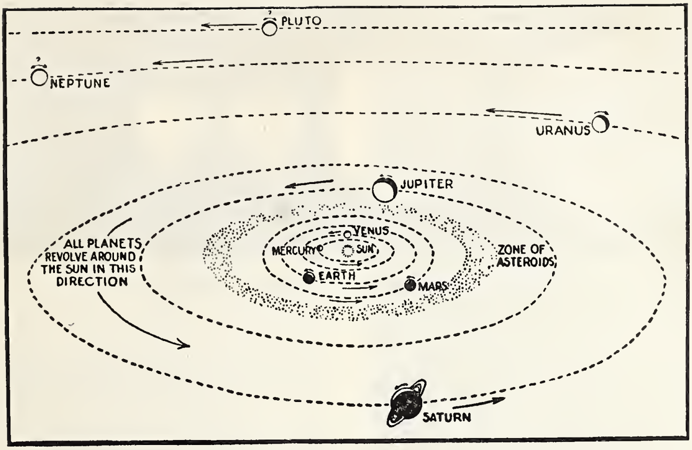


The first correct idea of the relation of the parts of the solar system to each other was worked out by Copernicus. When he developed his diagram, at least three planets had not been discovered.

covered. The largest of these is Ceres [sē'rēz], which is nearly 500 miles in diameter.

How are the planets arranged about the sun? Mercury, Venus, the earth, and Mars are the inner planets and are sometimes known as the earthlike planets. They appear in the order named. Ceres and other asteroids occur next. They are followed by the outer planets in this order: Jupiter, Saturn, Uranus, Neptune, and Pluto. The distances from the sun vary from 36 million miles for Mercury to 3670 million miles for Pluto. Since they do not follow exactly circular paths, these distances are only average. The sun is not located in the center of the orbits but is nearer to one side.

The light from Neptune and Pluto is too faint to be seen except with a telescope. Uranus, which is nearly two billion miles away, can be seen by a very keen eye. Others look like bright stars.



By comparing our idea of the correct relation of the planets with the ideas of Copernicus and Ptolemy, you can understand how scientific knowledge develops. Why are some of the orbits shown as incomplete curves?

How long does it take the planets to revolve in their orbits? The time required for the planets to revolve around the sun depends on the distance they are from the sun. The greater this distance, the longer the time required. Mercury, the planet nearest the sun, takes only 88 days to complete its revolution, while Pluto, the most distant planet, requires 248 years. If a human being could exist on Neptune or Pluto, he would not live long enough to have even one birthday.

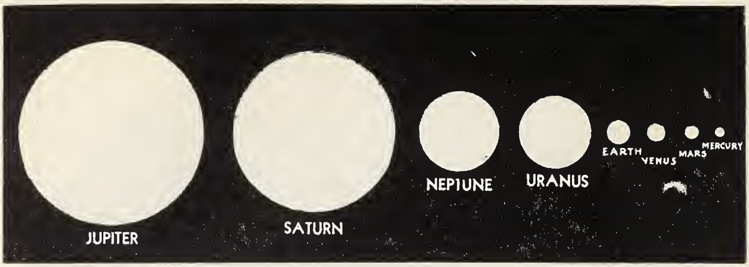
The following table shows the distance from the sun, the time of revolution, the diameter, and the time of rotation of all the planets.

141 1/2
93
48 1/2

How do the smaller and larger planets compare? The four smaller planets, which are near the sun, revolve around the sun in a much shorter time than do

3

PLANET	DISTANCE FROM THE SUN IN MILLIONS OF MILES	TIME OF REVOLUTION	DIAMETER IN MILES	PERIOD OF ROTATION
Mercury	36	88 days	3,000	88 days
Venus	67	225 days	7,600	(?) days
Earth	93	365¼ days	7,918	24– hours
Mars	141½	687 days	4,200	24 hours
Jupiter	483	12 years	87,000	10– hours
Saturn	886	29½ years	72,000	10 hours
Uranus	1,782	84 years	31,000	11 hours(?)
Neptune	2,793	165 years	33,000	16 hours(?)
Pluto	3,670	248 years	......	....



This diagram shows the planets in order of their size. Because the size of Pluto is not definitely known, this planet has been left out.

the more distant planets. The inner four planets have longer days than do the outer planets. The most marked difference of all, perhaps, is the difference in size between the inner four planets and the outer planets.

Complex laws have been worked out to describe by mathematics the relation of the distance a planet is from the sun and its speed of movement. By study of the planets and their moons the proofs for the law of gravitation were gradually developed.

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

All planets receive their light from the —1—, and because they all —2—, they have day and night. The first discovery of moons of another planet than the earth was made by —3—, who discovered the moons of —4—. Altogether —5— moons have been discovered. Ceres is an —6—. Pluto is about —7— times farther from the sun than is Mercury. The planets nearest the sun have the shortest —8— and the longest —9—. The planets —10— the sun receive the most heat.

3. What is it like on the other planets?

It is interesting to consider what the other planets are like. In our imaginations we have followed the adventures of people shown in comic strips and books. Many of them travel by use of rockets in space. In these books are drawn pictures of strange people—some small, some large, but all more or less like ourselves. You may wonder if there is any real truth to these exciting stories. A better understanding of the facts about the planets will answer your questions.

What is Mercury like? Not only does Mercury have the shortest year and longest day, but it also moves through its orbit at the greatest speed, travel-

ing at the rate of 29 miles per second. It is also the smallest planet and nearest to the sun. The fact that it makes only one turn while it revolves around the sun means that one side is always toward the sun. This side must be very hot, and the opposite side, which is always in the dark, must be extremely cold. There is no day and night on Mercury as we have them on the earth. One half of Mercury is light all the time, and the other half is dark all the time.

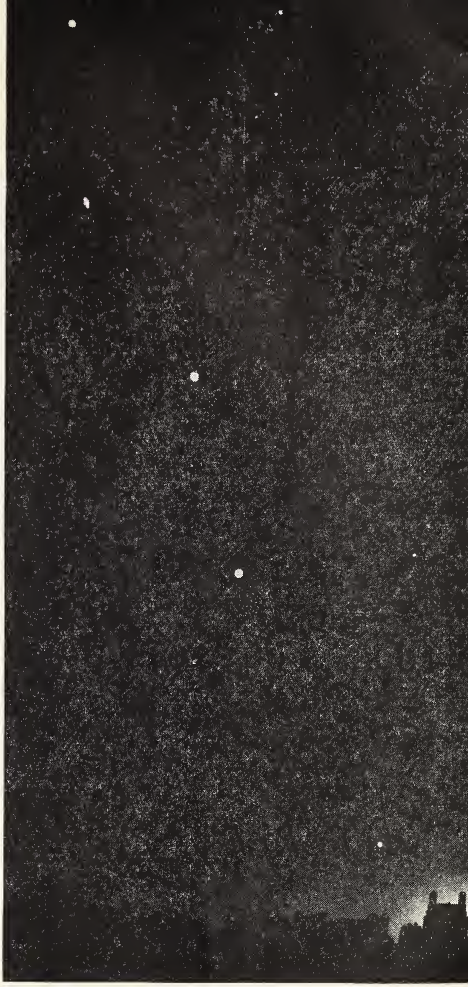
Observations show that there is neither air nor water on Mercury, and therefore there can be no life.

Mercury is so near the sun that it is difficult to see it with the naked eye. The best time to see Mercury is just after sunset when the sun is low in the west. At that time it is as bright as the brightest star.

Why is Venus called the earth's twin? If you will examine the table you will see that the only other planet that is anywhere near the size of the earth and has similar length of year and day is the planet Venus. Venus is most commonly known as the evening star and the morning star. This is because it is best seen just after sunset and just before sunrise.

Since Venus is nearer the sun than the earth, it receives more heat, and its atmosphere contains more vapor than that of the earth.

The distance of Venus from the earth varies. When farthest away, it is six times as far as when it is nearest. As a result, the brightness of Venus varies. When it is close to us, it out-



Yerkes Observatory

Only once in hundreds of years can five planets be seen in a line. Here are, beginning just above the skyline, Mercury, Jupiter, Venus, Saturn, and Mars, as they appeared just after sunset on March 1, 1940.

Yerkes Observatory

Because the planets are lighted by the sun, one half is always in darkness. When seen through a telescope, Venus looks much like the new moon.

shines Sirius, the brightest star, 20 times. During this period it can be seen in broad daylight. Venus goes through a series of *phases,* like the moon does, which can be seen with the aid of a low-power telescope.

Studies made of the planet Venus have never shown the presence of any oxygen in the atmosphere surrounding this planet. Since living things, as we know them, require oxygen to live, there probably could be no plants or animals on Venus.

Is Mars inhabited? Mars has water and air, and, while it is smaller than the earth, it has some conditions that have made many believe that there might be life there. Because it is further away from the sun than is the earth, the temperature is lower. Every night it probably gets a great deal colder than any winter weather known on the earth.

During the period when the northern part of the planet Mars is inclined away from the sun, a white spot appears around that pole. When the southern part is turned away from the sun, the white spot appears there. This has led scientists to believe that the poles are covered with snow during the Mars winter season. When it should be spring and summer on Mars, the white patches grow very small and the planet gets darker as though it were covered with vegetation. In the fall the planet begins to grow brighter, and these changes have been interpreted by some people as being due to the growth of plants and their decay during the fall. It is probable that the soil of Mars is chiefly an oxide of iron. It is doubtful that life such as we know it could be found on Mars.

It is possible that Mars today is like the earth will be billions of years in the future. On Mars, oxygen and water, which now

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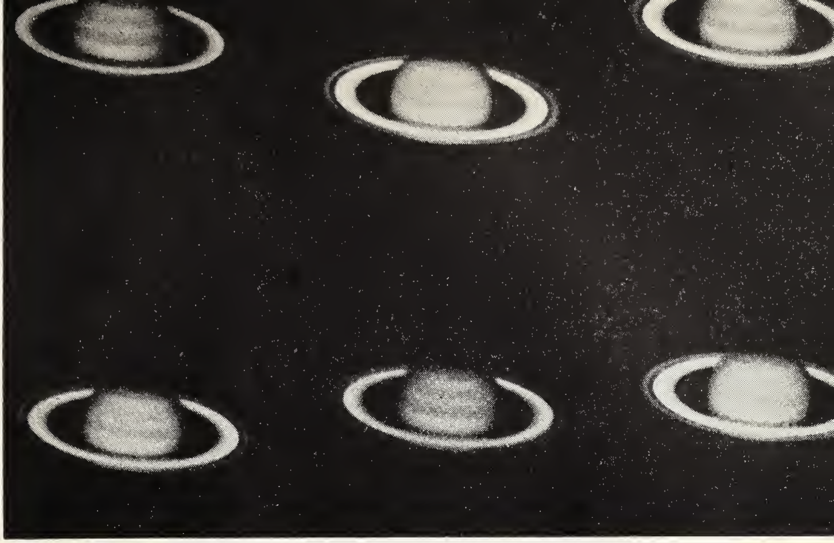
Mars has two distinguishing marks: the so-called canals and the ice caps. These, together with its red color, make it easy to recognize.



Mt. Wilson Observatory

These exposures of Saturn show the bands and rings which it alone among the planets possesses. Saturn is perhaps the most beautiful of the planets. All planets look round when seen through the telescope.

are very scarce, might have been abundant long ago. The valleys seen today, and once mistakenly called canals, were perhaps carved by rivers no longer in existence. The plants which exist on Mars are possibly like the lichens or simplest mosses that grow on rocks. These plants now grow only in the valleys of Mars along which water runs from the melting ice caps. If there were intelligent beings on Mars when conditions for life were more favorable, it is interesting to wonder what became of them.

One interesting feature concerning Mars is that it has two moons. The largest one is only 10 miles in diameter, while the smaller is about half as large. In addition to being very small, one of these moons rises in the west and sets in the east.

What are the other planets like? Jupiter is larger than all the other planets taken together. Its day is only 10 hours long. Its year has 10,500 days. Saturn is most famous for its rings. They can be seen by the use of powerful field glasses when the air is just right. Both Jupiter and Saturn have nine moons. Two of the moons of Jupiter are about as large as the planet Mercury, while others are the size of our moon or smaller. The air on these planets is so cloudy that no one has ever seen their real surface.

Uranus was not known to early students of the stars, because it is too faint to be seen

without a telescope except by people with very good eyes. Even with a telescope it looks like one of the fainter stars. Uranus has nearly four times the diameter of the earth. This measurement includes the air, because the atmosphere is so thick that astronomers have not been able to determine the exact diameter.

The planet Neptune was discovered when astronomers found that the orbit of Uranus was not quite what they expected. They reasoned that some other large body must be exerting an attraction on the planet. By a series of difficult calculations they were able to describe the direction in which astronomers should point their telescopes to find the planet. Shortly after these directions were known, the planet was found by a young German the first time he looked for it.

Pluto was the last of the planets to be discovered, being first seen in 1930. Its presence had been established by mathematical calculations for about 25 years before it was seen. Consequently, very little is known about it as yet.

How can we show the relative size of the planets? If we use a basketball to represent the sun, then the planets can be represented as follows:

PLANET	DISTANCE FROM BASKETBALL	OBJECT TO BE USED
Mercury	**40 feet**	**mustard seed**
Venus	**70 feet**	**grain of wheat**
Earth	**100 feet**	**grain of wheat**
Mars	**160 feet**	**mustard seed**
Jupiter	**520 feet**	**walnut**
Saturn	**1,000 feet**	**pecan**
Uranus	**2,000 feet**	**pea**
Neptune	**3,000 feet**	**pea**
Pluto	**4,000 feet**	**mustard seed**

Things to think about

Match the following subjects and predicates. Copy the sentences in your notebook.

Subjects

1. Mars
2. Jupiter
3. Mercury
4. Neptune
5. Pluto
6. Saturn
7. Uranus
8. Venus

Predicates

A. is the largest planet.
B. is the planet nearest the sun.
C. is the planet farthest from the sun.
D. is nearly the same size as the earth.
E. is the planet with rings.
F. may have oxygen in its atmosphere.
G. is the dimmest planet visible without a telescope.
H. was discovered by mathematical calculation.

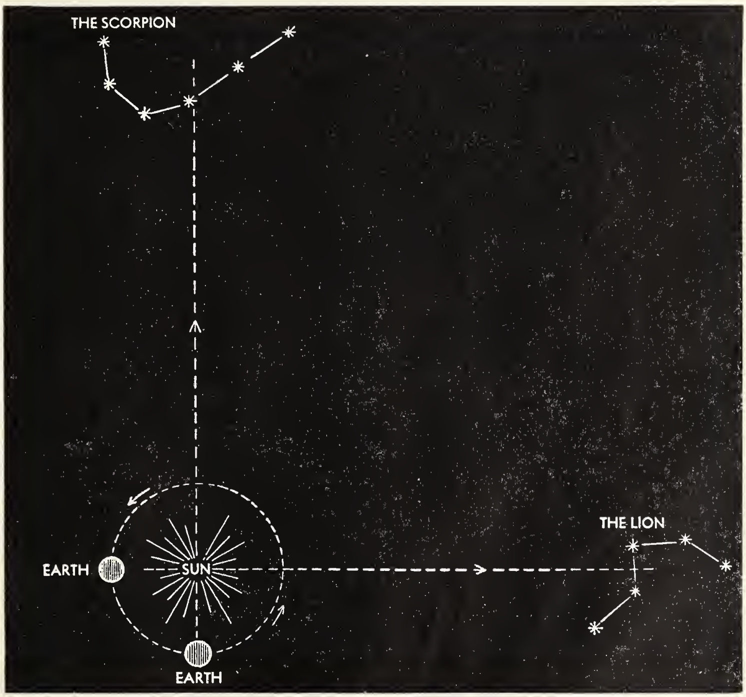
4. What is the sun?

Every living thing upon the earth depends upon the energy of the sun for food, water, and heat. The adaptations of all living things have been made in such a way that the energy of the sun provides for their needs. We ourselves are dependent upon the sun for fuel, building materials, clothes, light, and everything which makes life possible. Even the weather depends upon the sun.

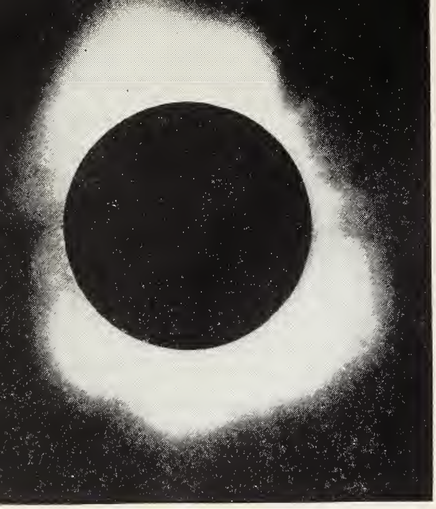
How far away is the sun? If it is difficult to appreciate the distances to the stars, it is nearly as hard to understand the enormous distance that separates us from the sun.

The actual average distance from the earth to the sun is about 93 million miles. A ray of light, traveling at the rate of 186,000 miles per second, reaches the earth in about eight minutes. 4

The distance from the earth to the sun varies because the sun is not exactly at the center of the



Because the earth revolves around the sun, the sun seems to change position among the stars. We say the sun is in the constellation Lion or Scorpion as shown in the diagram.



Mt. Wilson Observatory

The corona of the sun is seen during an eclipse of the sun. The black disk is the moon. Scientists do not know just what the corona is made of.

earth's orbit. We are about two million miles closer to the sun in winter than in the summer.

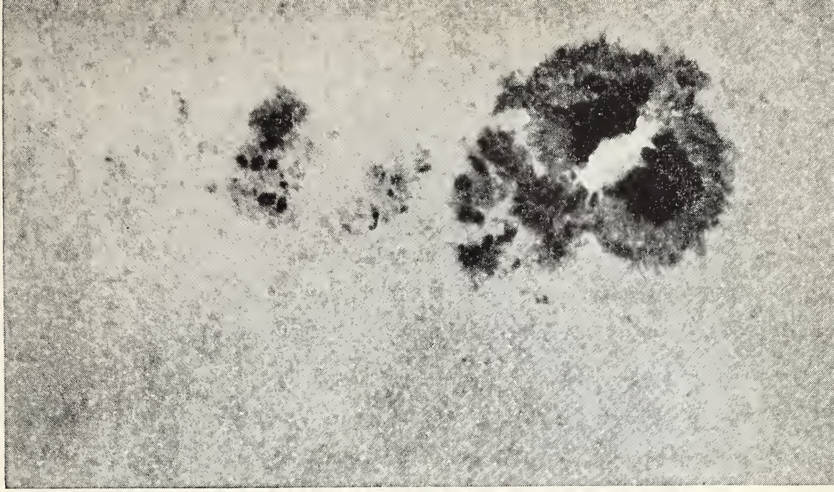
How big is the sun? If all the materials contained in the planets and their moons and other bodies associated with the solar system could be gathered together and added to the mass of the sun, it would not increase its weight by more than $\frac{1}{10}$ of one per cent. It is more than 100 times as far through the center of the sun as it is through the earth. Although the sun is composed of a mass of gas, it weighs as much as 330,000 earths. Over 1,000,000 balls the size of the earth could be placed within the sun if it were hollow.

By means of the spectroscope [spĕk'trō·skōp, a device for studying the color of light] astronomers have been able to determine what elements are found on the sun. They tell us that it contains nearly all the elements found on earth.

How hot is the sun? We know that if we heat gases by means of electricity, they will give off light. Helium is a gas which man has been able to heat enough in this way. All gases would produce light and other radiations if we raise the temperature high enough. We know that we get both light and heat from the sun, and therefore the gases must be quite hot.

The temperature of the sun has been determined by means of the spectroscope. It was found that the surface temperature is about 11,000 degrees Fahrenheit. This temperature is about equal to that obtained by the use of the electric arc. And the interior of the sun is hotter than the surface. Some astronomers think that this temperature may be as much as 500,000 degrees Fahrenheit. And the sun is not the hottest star!

A good measure of the heat of the sun is obtained by determining its heating effect on the earth. Scientists have found that when the sun is directly overhead and the air is clear, the amount of energy received by the earth would be more than 4,000,000 horsepower per square mile. By determining the total amount of surface of the sun, they have shown that each square yard of the sun's surface contributes 70,000 horsepower. Very little of this heat reaches the earth.



Yerkes Observatory

Sunspots look dark merely because they are cooler than the rest of the sun's surface. They are actually huge whirls of gaseous matter. This picture shows them as seen through a powerful telescope.

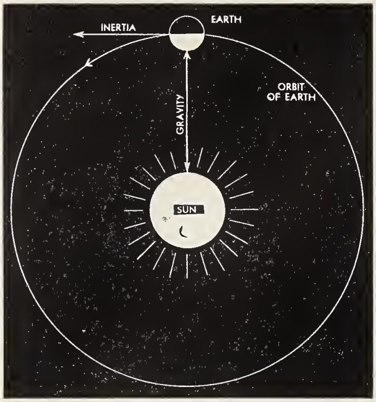
What are sunspots? When the sun is viewed through a telescope, dark spots can be seen on its surface. At times, the surface around these spots is greatly disturbed, as swirling masses of gas are thrown out from within the sun. The spots may last for a few days or for many weeks. It is thought that they represent storms on the sun similar to tornadoes which we have on earth. Some of the larger spots may be as much as 50,000 miles across.

Sunspots that last for a long time seem to move across the surface of the sun. By means of these observations astronomers have been able to show that the sun is turning around. They have learned that the center portion of the sun rotates once in about 25 days.

The sunspots are more active in some years than in others. Those who have studied the sun say that periods of great activity on the sun's surface return about every 11 years. During the period of greatest activity different spots are large enough to be seen without a telescope.

To look at the sun, the eyes must be protected. By using three or four layers of exposed camera film, you can look at the surface of the sun safely. It will appear as a round, red ball, and if the sunspots are large, they can easily be seen.

Do sunspots affect us? Sometimes teletypes [machines which set type and are controlled by telegraph] suddenly begin to write messages in which the letters are all mixed, and in other places telegraph and telephone



The earth moves along its orbit because of inertia and stays in it because of the gravitation of the sun.

communication is completely cut off. The cause of these disturbances is a severe electrical storm. At the same time the surface of the sun may show intense activity around many sunspots.

It is believed that the sun sends out electricity all the time but that it is more intense during the years when the sunspots are more active. Magnetic waves from the sun cut through telegraph wires producing electrical currents. It is also thought that static which interferes with radio reception is caused by electricity coming from the sun. When there are fewer sunspots, radios work better.

Astronomers have been able to show that many occurrences on the earth's surface are related to sunspot activity. Generally we have slightly cooler weather when there are more sunspots. Also, plants seem to grow better during that time. Measurements made on the annual rings of trees more than 2000 years old show that the periods of most rapid growth correspond to periods of greater sunspot activity.

Although these relationships seem to be true, scientists do not feel that they have tested the idea sufficiently to be able to use it for long-range weather forecasting.

12 **Have you ever seen the northern lights?** These displays are caused by electricity from the sun. The correct name for northern lights is aurora borealis [ô·rō′rȧ bō′rė·ā′lĭs]. It consists of streamers of light, sometimes colored, which move rapidly in the northern sky. The best time to see the aurora, or northern lights, is on a clear night when there is no moonlight. The best place is in the country where city lights will not interfere. The best displays occur in the spring and in the autumn and are visible in the far north.

Does the sun move through space? In addition to rotating about its axis, the sun, as one of the stars, is traveling at a rapid speed. Astronomers have determined that it is moving in the general direction of the star Vega at the rate of about 12 miles a second or a million miles each day. In this journey the sun, of course, is taking the earth and all other members of the solar system along with it. Every object in space seems to be in motion, but only those in the solar system revolve around the sun.

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

The diameter of the sun is about 100 times greater than that of the —1—. The distance to the sun is about —2— miles. The temperature of the sun's surface is about —3— degrees. The materials of which the sun is made are the same as those found on the —4—. At the temperature of the sun, all the substances there are —5—. The period of the sun's —6— is about one month. —7— are caused by electricity from the sun. Unusual displays of northern lights occur during periods of great —8— activity. By careful study of the surface of the sun, astronomers have been able to learn a great deal about the —9—. Life is possible on the earth because of —10— received from the sun.

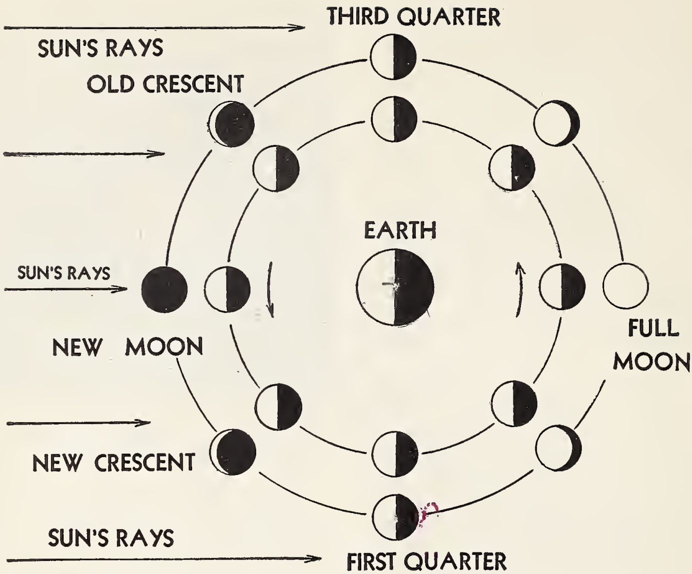
5. What kind of body is the moon?

The sun and the moon are both round and bright and look to be about the same size. However, the moon goes through certain changes different from any which occur on the sun. Because the light from the moon comes to us at night, people have come to think of it as one of the more friendly bodies in space. Also, because the moon appears during the night when mysterious things occur, it has been associated in many unfounded beliefs with changes of luck. The moon is closer to the earth than are any of the other bodies in space. It is 240,000 miles from the earth. This is only 1/400 as far away as the sun.

Of all the moons, ours is most nearly the size of its planet. Its diameter is more than one-fourth that of the earth (2160 miles), and it weighs about 1/80 as much as the earth. The moons of the other planets can be seen only by means of a telescope, but the earth and its moon would seem from other near-by planets to be a double star, plainly visible to the naked eye.

Where does the moon obtain its energy? We have seen that the sun gives off light because it is hot. The moon, however, is

The moon receives light from two sources. The crescent is lighted by the sun and the darker area by light reflected from the earth. The bright body above the moon is Venus.



The changes of the moon as they look to us are shown in the outer circle of moons. The inner circle of moons shows how the changes would look to an observer out in space.

cold, and has no light-giving power of its own. It shines merely by reflecting the light from the sun. Moonlight, then, is really sunlight. Since it receives its light from the sun, the moon can only reflect light from the side turned toward the sun. In the daytime, if the moon is in the right position, we can see it even though the sun is shining. Sometimes when the earth and sun are in the right position, light reflected from the earth may light up a part of the moon not receiving direct sunlight. We know from this that our earth can also reflect light.

Studies made of the surface of the moon lead us to believe that it is composed of bare rock.

Since there is no atmosphere on the moon, the sun shines directly on the surface without interference. The moon rotates on its axis once every 27⅓ days so that the sun shines continually on a given point on the moon for two weeks; then for two weeks it is dark at this point. With no atmosphere to scatter the sun's light and heat, the surface gets very hot, much hotter than boiling water. No life as we know it could possibly exist in such heat.

For the same reason the nights are very cold. That is, with no

blanket of atmosphere to hold the heat, the side away from the sun must be much colder than it ever is any place on earth. Because of the great heat changes and lack of atmosphere and water, there can be no life on the moon.

Can the moon change its shape? We commonly speak of four phases of the moon: new moon, first-quarter moon, full moon, and third-quarter moon. At various times, depending on the moon's position, we see different portions of the lighted half of the moon. Because of this, the moon appears to undergo changes in shape. When it is earth-lit, it is easy to see that the moon still has its old shape; it is always a sphere.

The moon revolves around the earth in a plane which is tipped slightly from that of the earth's revolution about the sun. It requires slightly more than 29½ days for the moon to change from new moon to new again. During this time the sun has shone on the half which is turned toward it. When the moon is on the side of the earth away from the sun, we see the completely lighted sphere; and when it is between us and the sun, we do not see it at all, since the dark side is toward us.

When it has moved one-quarter of the way around the earth, one-half of the illuminated [lighted] surface is visible to us. This represents one-quarter of the moon so that we commonly speak of this phase as the first quarter and of the phase two weeks later as the third quarter. The diagram on page 196 should help you understand the causes of the phases of the moon. As the moon moves around the earth, we see a gradual change in the amount of lighted surface. The visible portion gets larger and larger. At this time the moon appears to be lopsided. Gradually the sphere fills out until it is completely illuminated. Each night after that, less and less of the moon's surface is seen. The rounded phase disappears at the third quarter, and then the moon apparently becomes smaller and smaller, until finally a new moon begins the changes over again.

Just after the new moon, the whole surface of the moon can be seen in faint outline. A few days after the new moon, the moon again appears as a thin sliver, low in the western sky. It is then called a crescent moon. The curved points of the crescent always point away from the sun. If you could imagine the crescent moon as being a bow, the aimed arrow would point to the sun.

What is the moon's surface like? On clear nights, when the moon is beyond the first quarter, it is easy to see certain features on its surface. Large dark patches, surrounded by bright areas, appear. People in early times imagined these patches looked like figures or faces.

With a small telescope or a pair of reasonably strong field glasses, it is possible to examine these spots more closely. They

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Part of the surface of the moon is covered with circular craters; other parts are smooth plains called seas; and still other parts are covered with jagged mountains.

are actually caused by areas of dark rock which do not reflect the sun's light as well as the lighter rocks. When examined through larger telescopes, these dark areas appear as great level plains. Similiar areas can be found at the bottoms of craters. Mathematicians who have examined the pictures of the surface of the moon have been able to calculate, from the position of the sun and by measuring the length of the shadows, the height of the mountains which cover much of the moon's surface.

The various craters, the "seas" or flat areas, and the mountain ranges of the moon have been named. Near the moon's south pole there are mountains more than five miles high. It is believed that the craters are similiar to volcanic craters on the earth.

Some peculiar markings which look like rivers are probably cracks nearly a half mile wide and of unknown depth.

Proof that there is no atmosphere around the moon may be obtained from the fact that there is no twilight. If there were, the edge of the lighted surface would be broad, and we would be able to distinguish some features far into the dark half. As it is, the sunrise and sunset lines are sharp.

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

The moon revolves around the —1—. At —2— moon we can see all of the light half of the moon. At —3— moon none of the moon can be seen. One —4— of the moon is always light. The distance to the moon is much —5— than that to

the sun. The distance from the earth to the moon is about —6— miles. The diameter of the moon is about —7— miles. Nights on the moon are two —8— long. The diameter of the earth is about —9— times that of the moon. The moon shines by reflected —10—.

6. How do the moon's movements affect us?

We have seen that the sun provides the light and energy for all the planets and is the center about which they revolve. The planets in turn are the centers about which the moons revolve, and the whole system is rushing through space at a tremendous speed. Of all of these movements, we are most conscious of that of our moon. These movements cause variations in moonlight, eclipses, and tides.

What path does the moon follow? Measurements made with a telescope show that the diameter of the moon seems to change. Of course, this could not be possible; so the explanation of this apparently unusual condition must be that the moon is not always at the same distance from us. The moon is 31,347 miles farther away at its most distant point than it is when it is closest to us.

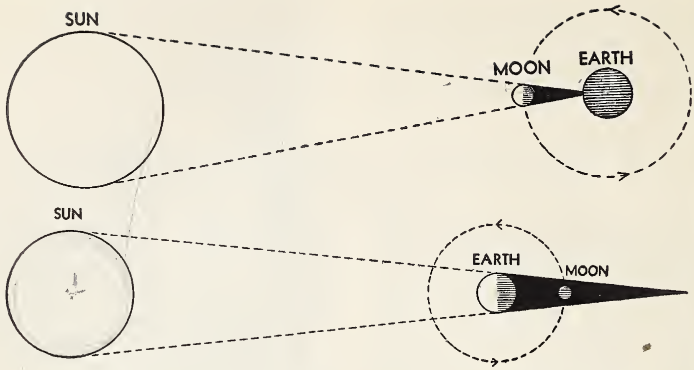
The moon is held in it's orbit by two forces: One is the attraction of gravity which exists between the two bodies. The other is its speed of revolution. Just as a stone tied firmly at the end of a string will keep the string tight when whirled around, similarly the moon pulls outward against gravity. Both the earth and the moon are attracted and fixed in their paths by the sun. Other planets, of course, exert some attraction on the earth and its moon as well.

How much of the moon can be seen? Since the moon makes one revolution about the earth in $27\frac{1}{3}$ days and turns once on its axis in the same length of time, we see the same side of the moon all the time. Consequently, no one knows what the other side of the moon is like. However, it is fair to assume that the appearance of this unseen half is probably about the same as the more familiar side covered with craters, mountains, and plains.

What causes eclipses? In order to understand an eclipse of the moon, we need to recall that the moon shines by reflected sunlight. Should anything come between the sun and the moon to cut off the sunlight, the moon would become dark, that is, it would be eclipsed.

In the eclipse of the moon, the object which cuts off the sunlight is the earth. Since the moon's orbit is tilted with respect to the orbit of the earth around the sun, at certain times the earth is in such position that it will prevent the sun from shining on the moon.

Another way to describe the



These diagrams will help you to understand why eclipses of the sun and moon occur.

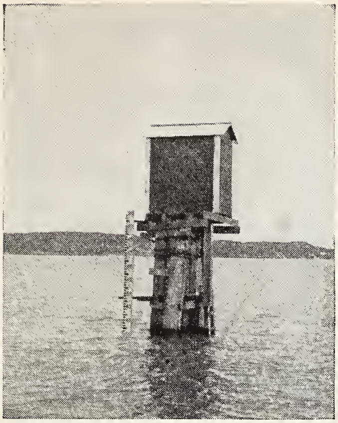
eclipse would be in terms of the earth's shadow. The earth casts a long, tapering shadow stretching away from the sun. This shadow is longer than the distance from the earth to the moon. Whenever the moon passes into this shadow, it is eclipsed.

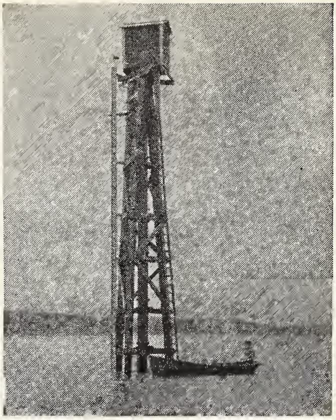
When the moon reaches such a position that it lies between the earth and the sun, the moon's shadow traces a path across the face of the earth, and the sun is eclipsed. This is just opposite to the condition which causes the eclipse of the moon.

One great difference between the two shadows is that the diameter of the moon is not large enough to cut off the sun's light over the entire earth. Yet the shadow is long enough to reach the earth. Those people who happen to live in the path of the shadow will find themselves in complete darkness. Outside the dark shadow there is an area of partial darkness in which the people can see a part of the sun. This occurs on either side of the shadow. Outside the path of the total eclipse or partial eclipse there is no eclipse.

Astronomers are able to foretell just when eclipses will occur, how long they will last, and on what part of the earth's surface they can be seen. Whenever the sun is eclipsed, astronomers make plans far in advance and organize expeditions to visit locations where the eclipse of the sun can be seen. A few years ago radio broadcasting companies sent announcers to these localities to broadcast the most interesting features of the eclipse. Now eclipses are sometimes shown on television.

How much gravity does the moon have? Because the mass of the moon is smaller than that of the earth, it does not exert as great an attraction upon other objects as the earth can. A boy or girl weighing 90 pounds on the





U. S. Coast and Geodetic Survey

At high tide (*left*) the water is many feet higher than it is at low tide (*right*) at Cook Inlet, Alaska. The two photographs show a range of 34 feet. An automatic tide gauge is protected by the house.

earth would weigh only 15 pounds on the moon. It would be easy to run and jump on the moon. If you could high jump four feet on the earth, you could jump 24 feet on the moon. The same muscles that make it possible to bat a baseball 100 yards here would be able to bat a ball more than one-third of a mile (about six city blocks) on the moon.

It is probable that the small force of gravity on the moon prevents it from having an atmosphere. It is not large enough to hold light gases.

What causes tides? The gravitation of the moon pulling on the earth is strong enough to move materials that are able to flow on the surface of the earth. Thus, the water in the ocean is drawn in and out over the beaches each day. This regular movement of the water is called the tide.

As the water moves in, the depth at a given point becomes greater and low objects are covered. For this reason the high tide is called the flood tide. When the water goes back to its lowest position, it is called the ebb tide.

The pull of the moon on the water acts at the same time on both sides of the earth so that this movement in the water will occur on both sides at the same time. Because of this, any place along the ocean will have two high tides and two low tides each day.

The sun also exerts an attraction on the water of the earth. At certain times the sun and moon pull together. During these periods when the moon is full and at new moon we have the highest tides. They are called

spring tides. When the moon is at either first or last quarter, the sun and moon pull against each other. At these times the tides are lowest and are called neap tides.

The average distance in vertical height between the low and high tide is about two feet, but the height varies greatly at different places. In the Bay of Fundy, tides of 70 feet have been recorded. The exact time between two high tides is 12 hours and 25½ minutes. A higher tide is followed by a tide not quite so high. The difference, then, between each of the high tides is 24 hours and 51 minutes. Since it is 24 hours and 51 minutes from moonrise one day to moonrise the next day, we have evidence that the moon is the chief cause of the tides. Actual measurement of the moon's gravity also proves this fact.

Tides are useful in some ways. They help to remove decaying materials along the shores, and during low tide they expose clam and oyster beds for fishermen. In some parts of the world good harbors are cut off by shallow entrances. Vessels are able to enter and leave such harbors at high tide. In some places the power of the tides has been used for water power. During high tide reservoirs are filled, and at low tide the height of the water is sufficient to turn power wheels.

When does the moon rise and set? Because the new moon is in line with the sun, it rises and sets at about the same time the sun does. When you see a new moon in the evening, it is setting. The full moon is directly opposite the sun, and rises just as the sun sets, and shines all night. The first quarter moon rises at noon, and the last quarter moon rises at midnight. Each day the moon rises about 51 minutes later than on the preceding day. If you want to know if there will be moonlight for a picnic, you can count the days and figure the time of moonrise from any given day following a new moon. The average time at which the new moon rises is 6 A.M.

Things to think about

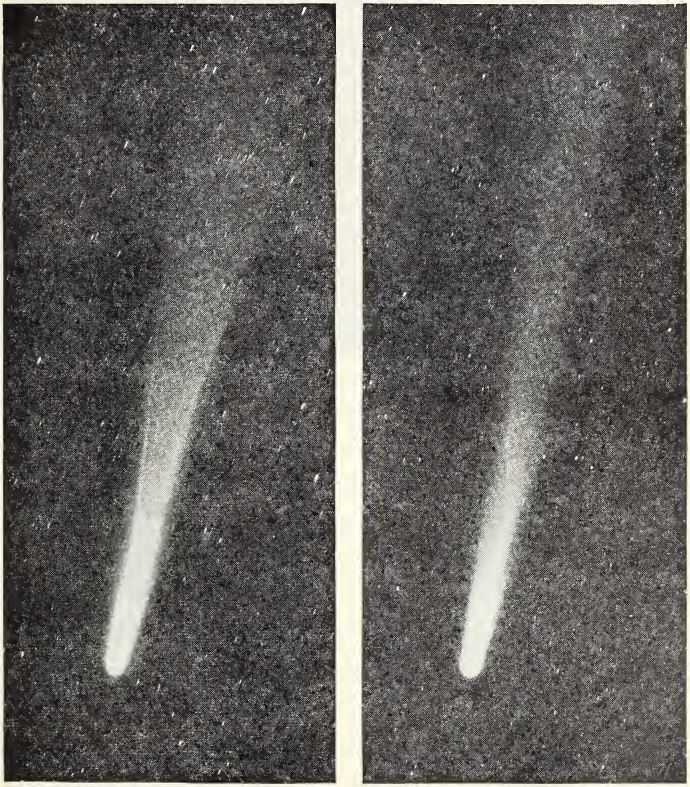
Copy the following paragraph in your notebook. Complete the sentences.

When the —1— is eclipsed, the earth gets between the moon and the sun. When the —2— is eclipsed, the moon gets between the sun and the earth. The path which the moon follows is its —3—. —4— are caused by the combined force of the attraction of the moon and the sun for the earth. Only one —5— of the moon's surface has been seen. The force of gravity on the moon is only one —6— of that on the earth. It takes the moon —7— days to revolve around the earth. It takes the moon —8— days to rotate. In eclipses of both the moon and the sun, something cuts off the light of the —9—.

7. What other bodies are in the solar system?

One of the most startling events which takes place in the sky is that of the eclipse of the sun. Primitive people were terrified, feeling that it foretold the end of the earth or other equally terrible happening.

Another event which many unnecessarily feared as a possible cause of death or even the end of the world is the regular return of comets. In 1910 many people were filled with fear by the announcement that the earth would pass through the tail of a great comet. When it could be seen,



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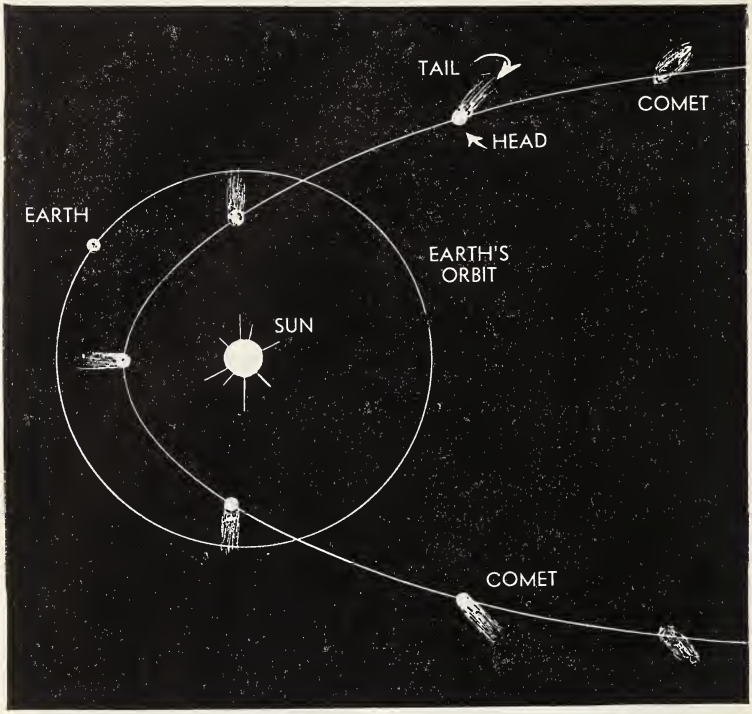
A photograph of a comet shows it to be made up of a bright head and a tail so thin that stars are visible through it. Stars appear oval because the camera was moved to follow the comet.



A comet forms a head and tail as it nears the sun and loses them as it moves into a distant space. The tail always points away from the sun.

some thought that it was heading straight for the earth and that the collision which might occur would surely destroy everything. A few believed that the tail was filled with poisonous gases, which would certainly destroy all living things. Had they known anything about these space travelers, they would never have had such foolish notions.

What are comets? Perhaps the most interesting thing about a comet is its shape. It has a tail. The word comet comes from a Greek word, "coma," which means hair. Since the tails look like long strands of hair, the bodies were named comets. These tails can only be seen when comets are near the sun. Regardless of the direction of motion of the comets, the tails always point away from the sun. The tails are not solid since the stars can be seen through them. It is thought that they are composed of very thin particles, and that each time a comet passes the sun, some of the material in the tail is lost.

There would be no great shock if the earth were to collide with a comet because we have learned

that the comets are not solid bodies but are made up of many small particles, none of which may be larger than a marble. While they are all confined within the area of the head, they may be as much as half a mile apart.

Some of the comets are larger than many of the planets, yet the pieces in a comet are so small and so far apart that the weight of the comet is very light.

Only a few really spectacular comets have appeared, and perhaps the one which made the greatest display and was seen by the most people was the one in April, 1910. It was named Halley's comet after Edmund Halley, an Englishman who lived about the same time as Sir Isaac Newton and saw the comet for the first time in 1680. He believed the comet followed a regular path and forecast its reappearance. It was also seen in 1759 and 1835.

What paths do the comets follow? Actually we know the average time of revolution of Halley's comet is about 77 years. This varies somewhat because of the effect of the planets upon its motion. The paths of many comets have been studied and charted. They all swing about the sun in orbits just as the planets do, but these orbits are much narrower than any of those of the planets. The period of revolution varies tremendously. One of the faintest comets, which can only be seen with a telescope, travels through a complete revolution in about four years. Others may take several hundred years.

The speed of the comet varies greatly as it travels through its orbit. Halley's comet takes more than half of its period to get around the outer end. As it moves towards the sun it begins to gather speed. By the time it reaches a point where it can be seen from the earth, it is moving fast enough that its motion is quite obvious. It takes only a short time for it to complete the circle about the sun, and in only a few months it can no longer be seen with the unaided eye. When closest to the sun, it is far inside the orbit of the earth.

What are meteors? Other objects which are quite commonly seen are the "shooting stars." Of course they are really not stars at all, but are meteors [mē′tė·ẽr]. Meteors are particles of rock or dust which are attracted to the earth from outer space. Most of them are actually smaller than the head of a pin. The large meteors look as bright as stars because they are so close to us.

As these particles enter the earth's atmosphere, they are heated by their movement through the air until the surface begins to glow. They are first seen shortly after they enter the earth's atmosphere and may burn themselves up about 50 to 60 miles above the earth's surface. Their speed varies from 10 to 50 miles a second.

Astronomers have been able to learn about the earth's atmosphere by observing these meteors. They can be seen on any clear evening, although at cer-

American Museum of Natural History

This 36½-ton meteorite is the largest in any museum. It fell in Greenland.

tain times they fall in greater numbers. When many meteors fall within a short time, their falling is commonly called a meteor shower. By observing the direction of fall, it is possible to determine the area in the sky from which they seem to come. Some of the heaviest showers have been sufficiently thick to light up the sky over several states.

Astronomers have estimated that about 20 million meteors fall to the earth each day. They believe that these showers come from comets that have been broken up. Most meteors are completely burned before they reach the surface of the earth, but some of them are so large that they are not entirely burned up. A portion may reach the earth. The oxides formed by burning fall to the earth also.

What are meteorites? The unburned remains of meteors are called meteorites. Most of them are very small, but some are large. One of the largest ever to fall was about 36 inches long and 26 inches high. Of course this is only part of the whole meteor. This meteorite is in the Chicago Museum of Natural History.

At the speed meteorites travel, they are broken into pieces by the explosion which occurs when they strike the earth. These explosions have been great enough to form craters of considerable size at various places over the earth. The largest in the United States is Meteor Crater near Winslow, Arizona (page 210). It is 4000 feet across and 600 feet deep. It is thought that the meteorite which formed this crater was made of iron. Only very small pieces have ever been found.

The craters are generally oval shaped, and their shape shows the direction from which the meteor came. In northeastern states airplane pilots have been able to identify many small meteor craters not noticeable when on the ground.

It has been estimated that only about 150 meteorites fall in the United States each year. Just a few of these are ever found. The chances are very small for one of them to hit a person. No one has ever been known to have been struck by a meteorite.

Large meteors come close to the earth. Many are not seen until they explode and light the sky. Some may have been as close as 10 miles from the surface. The explosion makes a noise louder than thunder. The height at which the explosion takes place can be determined from the time

which passes between the burst of light and the sound.

After the explosion the falling particles are quite dark. This indicates that the metal was heated only on its surface. Since these pieces fall only a comparatively short distance, they are not hot when they are picked up, even immediately after falling.

The meteorites are composed of a certain type of stone. Some of them are made of iron ore. The very large meteorites are going sufficiently fast when they hit the earth to bury themselves deeply. Consequently, only a few have ever been found. The largest meteorite in any museum is called the Cape York. It was found at Greenland by Admiral Peary, who brought it to New York City where it is exhibited in the American Museum of Natural History.

A larger one lies where it fell in South Africa. No one knows when it fell or just how much it weighs. It is thought that its weight must be about 70 tons.

Things to think about

Match the following subjects and predicates. Copy the sentences in your notebook.

Subjects

1. Comets	6. Meteors
2. Comets	7. Meteors
3. Comets	8. Meteorites
4. Comets	9. Meteorites
5. Comets	10. Meteorites

Predicates

A. pass through the earth's atmosphere.
B. have tails.
C. revolve around the sun.
D. are unburned portions of meteors.
E. have long and narrow orbits.
F. fall to the earth's surface.
G. have heads made of scattered rock particles.
H. are heated by friction with the air.
I. glow because of the action of energy from the sun.
J. may form craters when they strike.

A review of the chapter

Superstition and ignorance made it impossible for people of ancient times to develop correct explanations concerning the movements of the members of the solar system. Many of their mistaken ideas became the foundation for modern frauds and superstitions. Now we know that the stars are not located at the same distances from us, nor are they of the same size and degree of hotness. We know that a planet appears to be larger than the stars only because it is comparatively close to us. We know that the earth, instead of being the center of the universe, is only one of nine planets revolving regularly and in fixed or-

bits about the central body, the sun.

Because of its huge size, the sun controls the motions of the planets and influences conditions upon them by the amount of heat given off to them. While our moon regulates the tides on the earth, and has certain other effects, we know that it is one of 28 moons in the solar system. Further, the eclipses of the sun and moon are natural events and that comets are regular visitors having unusual appearances and orbits. Altogether, the earth is a very small object in a vast system of stars and space.

Word list for study

Be sure that you can pronounce, spell, define, and use in a sentence every word in this list. Each of these words has been defined or explained and used in this chapter.

planet	crater	orbit
solar	magnitude	plane
revolution	rotation	gravitation
asteroids	sunspot	aurora borealis
phase	annual rings	eclipse
astronomer	diameter	spring tide
neap tide	comet	meteor
meteorite		

An exercise in thinking

Below are two groups of sentences. The first group contains principles, which are large general ideas. Each sentence in the second group contains an idea related in some way to one of the principles in the first group. Write the numbers from 1 to 35 on a piece of paper or in your notebook. Find the principle which best explains the idea in the second list. Then after the number on your paper write the letter before the related principle.

List of principles

A. Moons are controlled by the planets about which they revolve.

B. The rotation of the earth at an inclination of $23\frac{1}{2}$ degrees is the cause of day and night and the difference in their length.

C. The sun is the source of light and heat in the solar system.

D. The length of the planet's year depends upon its distance from the sun.

E. Gravitation is the attraction of every object in the universe upon every other object.

F. Tides are caused by the gravitation of the moon and the sun.

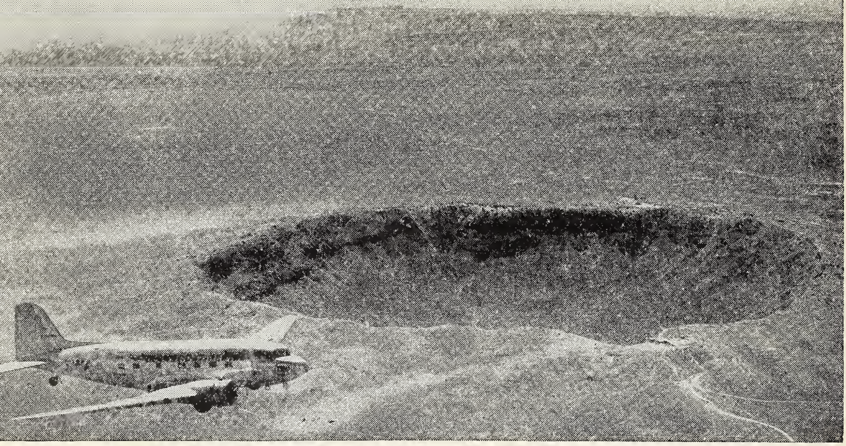
List of related ideas

1. The sun is eclipsed when the earth passes into the moon's shadow.
2. One half of the earth is always light.
3. Twice a day water flows up over low beaches.

4. June 21 is the longest day in the year.
5. It takes the earth 365¼ days to revolve around the sun.
6. During December the sun reaches its lowest point in the sky at noon.
7. The moon shines by reflected sunlight.
8. A day is the time it takes for the earth to rotate.
9. The moon revolves around the earth in 27⅓ days.
10. Pluto receives much less heat than does Mercury.
11. Days and nights follow each other in regular order.
12. During July the sun rises north of east.
13. The temperature of the sun's surface is about 11,000 degrees Fahrenheit.
14. The sun is near the center of the orbit of every planet.
15. It takes Mercury 88 days to revolve around the sun.
16. The moon is eclipsed when it passes into the earth's shadow.
17. The planets revolve around the sun, but their orbits change as they come near other planets.
18. You pull upon the earth with a force equal to the force that the earth exerts on you.
19. When the moon is between the earth and the sun, it is an eclipse of the sun.
20. Gravitation and their speed of movement keep the bodies of the solar system in place.
21. Jupiter has nine moons.
22. The planets cannot escape from the solar system.
23. The year on Mars is longer than the year on the earth.
24. The time between two consecutive high tides is about 12½ hours.
25. Vertical rays of the sun give more heat than do slanting rays.
26. A person would weigh less on the moon than on the earth.
27. The sun is directly above the equator only two days a year.
28. There are two high tides at the same time on opposite sides of the earth.
29. The sun is higher in the sky at noon during summer than during winter.
30. The speed of Mars about the sun is greater than is that of Jupiter.
31. The highest tides are called spring tides.
32. The force of gravity on the sun is 28 times as great as it is on the earth.
33. The moon is a cold body.
34. The planets shine by reflected light.
35. The sun rises in the east and sets in the west.

Some things to explain

1. Why cannot you see the stars during the day?
2. Why are the claims that stars and planets influence a person's life absurd?
3. How does the modern view of the motions of bodies in space differ from the ancient belief?
4. Why is it difficult to see the planets that are between the earth and the sun?
5. Why do we never see Venus at midnight?
6. How much time would be required to reach the nearest planet in a jet plane traveling one thousand miles per hour? Explain.



Douglas Aircraft Company, Inc.

It is believed that a meteor struck the earth and buried itself in this huge pit. This is Meteor Crater in Arizona. (See page 206.)

Some good books to read

Baker, R. H., *When the Stars Come Out*

Bernhard, H. J. and others, *New Handbook of the Heavens*

Fisher, G. C., *Story of the Moon*

Meyer, J. S., *Picture Book of Astronomy*

Reed, W. M., *Stars for Sam*

Skilling, W. T. and Richardson, R. S., *Sun, Moon, and Stars*

Swezey, G. D. and Gable, J. H., *Boys' Book of Astronomy*

Writers Program, *Light of the World*

CHAPTER

6

The Changing Earth

Suppose you were sitting peacefully beside a small lake. Your uncle, a geologist, starts talking. "You might not realize at first glance that the granite which forms the boulders around this lake, and the sand of its beach, oozed up in a melted state from deep in the earth. You noticed those sweeping hills on either side of the lake, of course. They were deposited by the wind which blew dust over this region for a long time after the melted rocks cooled. Then much later the great ice sheet which covered the northern part of the earth melted. Its running waters swept away a channel through the dust hills and cut into the rock. That ridge of granite at the north end of the lake is an ancient waterfall, and this lake itself is the deep pool left at the bottom of the old falls."

You would probably believe your uncle, because of his training as a scientist. But you certainly would not see at once all the clues which to him would tell a story of the formation of the earth since ancient times.

Some activities to do

1. Make a salt garden. Obtain a lump of coke or coal and a bowl. Put a cup of water in the bowl and a half a cup of salt. Add coloring such as bluing, mercurochrome, or ink. Let it stand for several days or weeks. Observe changes that occur.

2. Obtain several small rocks of different kinds. Heat each over a burner until it is quite hot, and drop it into cold water. Keep your face well back from the water when you do this. Why? Observe which rocks are most affected and which are least affected.

3. Make an artificial sedimentary rock by using cement or plaster of Paris to hold together particles of sand and small pebbles. How can you make your rock form in layers?

4. If a place can be found where it will freeze, fill a bottle completely full of water, and freeze it. Observe what happens to the bottle. If you can obtain ice and salt you can pack a mix-

ture of these materials around the bottle and freeze the water. Explain.

5. Examine rocks found outdoors in different places. Obtain pebbles from streams, rocks from road cuts, and bits of larger surface rocks. Note differences in the way they have been weathered.

6. Start a Rock Exchange Club. Write science classes in regions with rock formations different from those of your region. If you live in a limestone region, exchange with some class which lives in a lava region, for example. Label the samples you send, and tell where you found them. Small samples are much less expensive to ship.

7. Take a walk in some area not covered with houses or fields, and observe the rocks and soil, particularly in cuts along roads, along stream banks, and along cliffs. See if you can find rocks which have been folded, or rocks which show action of water. Can you find rocks containing shells of animals?

8. Obtain a garden hose, and sprinkle various surfaces with a gentle spray of water. See if you can observe the formation of a stream. Do you know why waterfalls are formed?

9. If you started a rock collection last year, add to it and improve it. If you have no collection, start one, and classify all your rocks into the three classes mentioned in this chapter.

Some subjects for reports

1. The formation of the region in which you live
2. Growth of the drainage system where you live
3. The most interesting rock formation I have seen
4. Various caves and their unusual formations
5. Natural bridges and how they were formed
6. The world's biggest volcanic explosions
7. The formations of Yellowstone Park
8. Soil conservation problems where you live

1. How does the earth's surface change?

Just as you cannot read a code message until you know what the code is, you cannot read the stories plainly told in rocks without knowing what the signs mean. One sample of rock may be enough to tell you how it was formed. Finding layers of rocks in their natural order may tell you all you need to know about the recent history of the region. The word "recent" in the study of the earth may cover millions of years.

What stories do melted rocks tell? There is a large group of rocks which have been formed by cooling directly from the melted state. These are the igneous [ĭg′nė·*ŭ*s] rocks. There are two common types of igneous rocks: the granites and the basalts [b*ȧ*·sôltz′]. A number of interesting clues regarding changes of the earth's surface may be found in a study of these rocks.

Igneous rocks are made up of crystals. If the crystals are large

and coarse, as are those of granite, it is probable that the rock was formed deep in the earth, and cooled slowly under pressure. If the crystals are fine grained, it is probable that the rocks cooled rapidly at the surface of the earth. Some igneous rocks contain both fine and coarse crystals, which indicates that the rocks started cooling underground and then flowed to the surface. One kind of rock, obsidian, cooled so rapidly that it has no crystalline structure at all, but looks like glass.

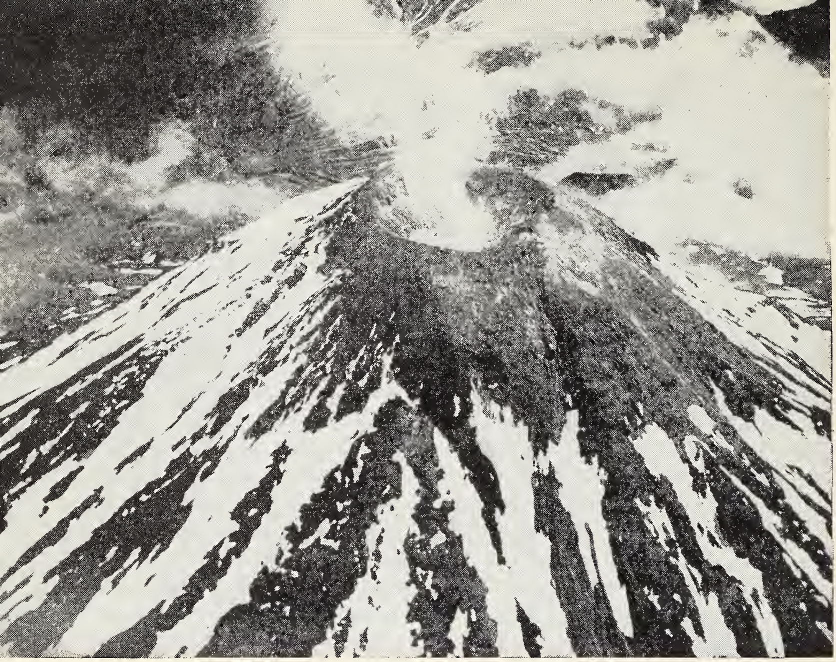
The basalt rocks contain iron and other chemicals not found in granite. Basalt rocks often cool in the form of six-sided, closely clustered columns, such as are found along the Palisades of the Hudson River. When you see such a rock formation, you know that the rocks are igneous, and were probably cooled after they flowed to the surface of the earth.

When you find a coarse-grained granite at the surface of the earth, you can conclude that it was formed beneath the surface but has been exposed by erosion of the overlying rocks.

Sometimes melted rock does not flow to the surface, but spreads underground. If the rock flows through a crack horizontally and cools, the resulting layer of igneous rock is called a sill. If the melted rock flows through a vertical crack, it forms a wall between the older layers of rock, and is called a dike. When the surrounding rocks are eroded

U. S. Geological Survey

This is a volcanic dike. Melted rock under pressure was forced upward into a crack in softer layers of rock, which now are partly worn away.



Robinson Studio

This is the crater of a volcano in Alaska. Steam can be seen rising from it.

away, the dike may remain as a huge wall of forbidding rock. Small dikes may appear merely as streaks in other rocks.

Lava is the melted rock that issues from volcanoes. If it flows over the earth, it covers other rocks. Some men digging a well through igneous rock once came upon a layer of sand in which scorched tree trunks were buried. You can easily understand what had happened there long ago. In the Pacific Coast and Mountain states there are many evidences of the flowing action of igneous rocks.

What stories do water-formed rocks tell? The sedimentary [sĕd′ĭ·mĕn′tȧ·rĭ] rocks were formed under water. They consist either of materials deposited from water or of skeletons and shells of animals. Sea animals form skeletons by taking the necessary minerals from the sea water in which they live.

Most sedimentary limestone rocks were formed under ocean water. Therefore the huge layers of limestone which cover a large part of the United States give us definite evidence that the land on which we now live was once part of the ocean bottom. You can see for yourself the shells of ancient sea animals in many kinds of limestones. We can judge how deep the ocean was by the kind of shells we find in the limestone.

Some sedimentary rocks con-

sist of pebbles and finer materials mixed and cemented together. These rocks, called conglomerates [kŏn·glŏm′ẽr·ĭt], must have been formed at the bottom of a slope where the coarse materials of which they are made were carried by a fast-flowing stream. We know that sluggish streams cannot carry pebbles any distance.

If the rock is a sandstone made of well-sorted sand particles, it is reasonable to conclude that they were deposited in a stream bed or along a shore. If the particles are very fine, it is likely that the water carried the sand a long distance before it settled.

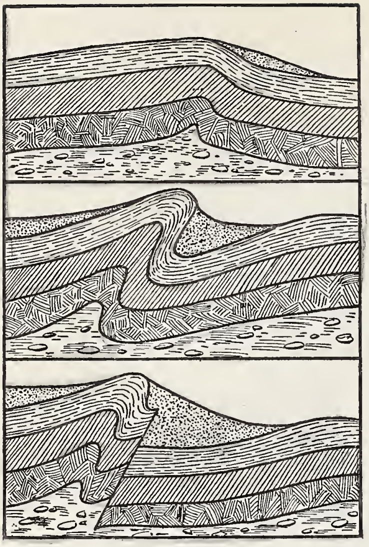
If the grains are still finer and are made of materials which stick together when wet, it is likely that they were formed still farther out from the shore. These fine particles are usually clay and form shale rocks. If a shale has black streaks in it, it was probably formed where there was vegetation, for black soils contain vegetable material.

It is sometimes possible to find places where there are sudden changes in the types of sedimentary rocks in different layers. Such sudden changes indicate a similar change in the surface of the earth. If a layer of rock made from wind-blown sand is covered by a layer of shale, it is an indication that the land was lowered beneath the water or that there was a flood when the shale was formed. If there is a layer of conglomerate above the shale, we can assume that near-by regions were elevated to make possible the fast-flowing streams necessary to form such deposits.

Sometimes sedimentary rocks of one type are tilted sharply, and sedimentary rocks of another type lie in horizontal layers across the ends of the first layers.

The normal order in which the materials are deposited when a river flows into the ocean is first the pebbles, then the coarse sand, then the fine sand, and finally the clay. If the sand sinks beneath the ocean, it may be later covered by limestone. As a highland is worn away, the slope of the stream becomes less and less steep, and materials are deposited in normal order. If the land is raised during the process, the order may start over again before the first process is complete. If the land sinks below the ocean, limestone may be deposited on coarse sandstone or conglomerate.

How have rocks changed form? Rocks may be changed in form by the action of heat, water, or pressure. All three of these forces may work together to change rocks. Limestone may be changed into marble. Changes of this kind usually take place below the surface. Shale similarly may be changed into slate. If the slate is black, the shale probably was formed from clay materials containing vegetation. The changes which take place in rocks may be compared to the changes produced by baking clay to form bricks. Rocks which have been changed in form are called metamorphic [mĕt′ȧ·môr′fĭk] rocks.



Folding of rocks goes on very slowly. The pressure of the shifting crust of the earth causes a fold to start, then it folds more sharply, and finally may fault—that is, crack and slip.

How do rocks indicate surface movement? If a sill or dike of igneous rock is broken off sharply and then continues on a different level, we have proof that the surface of the earth moved after the flow of molten rock ceased.

In areas where the surface rocks do not indicate that the land has moved, the reports of well drillers are of value. Samples obtained from wells may show the presence of certain kinds of rocks over areas hundreds of miles in extent. At St. Peter, Minnesota, a bed of sandstone appears at the surface of the ground. Farther south samples of the same rock are found by drillers at depths of several hundred feet. In eastern Nebraska the same sandstone is found in drillers' samples at a depth of nearly 5000 feet. Since the sandstone was probably deposited on the level, it is apparent that there must have been widespread movement of the earth's surface at some time since the rock was formed.

While layers of rock are frequently tilted by pressure, it is more common to find that they are bent. It is impossible for a rigid rock to bend suddenly. Even when bending is very gradual, cracks appear in the rocks. It is possible, if there is enough pressure and if the movement is gradual enough, that some rocks will actually bend without cracking. Examination of folded sedimentary rocks will show whether they bend or crack as they are acted upon by the changing surface of the earth. Careful study of clues is essential if we are to know what changes have taken place in the earth's surface.

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

Rocks which have changed in form are —1— rocks; those which cooled from the melted state are —2— rocks; and those which were deposited from water are —3— rocks. Water-deposited rocks are formed from —4— or from the skeletons or —5— of animals. If conglomerate rock overlies shale, a near-by place was —6—. Walls of igneous rock between other rock

E. Geyer, Aletschwald, Switzerland

Glaciers not only weight down the earth but move huge masses of rock materials. Here two glaciers have joined, showing their dividing line by the presence of rock materials each carries along its edge.

layers are called —7—. Large crystals are formed in rocks from —8— cooling. —9— rocks contain iron and other minerals.

2. What forces cause the land to move?

Although we know that the surface of the earth is slowly but constantly shifting, it is rather difficult to find the exact causes of this movement. We know, however, that the land actually moves. The change from land to ocean and back again is not caused by drying up and re-forming of the oceans.

If all the ice should melt from near the North and South Poles, there would be more water in the ocean, and the water would cover more of the land. If more ice were frozen in the glaciers, there would be less water to fill the ocean and more land would be exposed. But on the average, the level of the ocean remains constant for thousands of years.

Do we know that the earth's crust moves? Today it is possible to find on hillsides, far removed from any ocean, old beaches and cliffs that were formed by the cutting action of waves. You might think that these waves were in a large lake if you did not find on these old beaches shells of animals that live only in salt water. Since there are very

few salty lakes in the world, the work must have been done by ocean waves.

Near Pompeii, in Italy, an ancient temple, built on land 1800 years before, was exposed by digging. It was found that certain sea animals had bored holes in its marble columns at a height of many feet. This temple not only had been lowered into the ocean by the sinking land, but later had been raised above the sea by rising land. Then soil had been deposited from the ashes of the volcano Vesuvius, covering the temple.

There are many high mountains of rocks built from the shells of animals which live only in salt water. Such limestone rocks are common in many parts of the United States.

When land along the seacoast is sinking, it is natural that the lower places should fill with water first. Along our Atlantic Coast there are old river valleys which have disappeared under the ocean. The Hudson Valley has been traced under water by measuring the depth of the ocean for more than 100 miles southward from New York Harbor. Many of the best harbors result from ocean water filling valleys as the land sinks.

The land may rise or sink far inland. In Missouri a large area of land, once part of the flood plain of the Mississippi River, has sunk and is now covered by a lake.

The earth's surface moves sidewise enough that the movement can be measured. Scientists of the United States Geological Survey find that this sidewise movement of the land can be noticed in the mountains along the Pacific Coast.

What causes land movement? It is possible that the earth, in cooling very gradually, is contracting as it cools. If this theory is true, the interior of the earth is gradually shrinking, leaving the surface of the earth too large to fit. As the interior shrinks, the surface settles, shifts, and tilts, causing some parts to be raised, while other parts are lowered. If you have seen the wrinkled skin of a baked apple which shrank from being cooked, you can picture the way the earth's surface folds.

It is possible that some movement of the earth's surface is caused by melted rock flowing upward from the interior of the earth, pressing up beneath the rocks near the surface and lifting them.

It is also possible that as materials are moved on the surface of the earth by rivers and glaciers they cause the surface of the earth to become heavier in some places than in others. These materials, pressing down on the lower layers of rock, force other lighter materials near by to move to make room as they settle. The lighter materials may move sidewise for a time, but will also be forced upward by the crowding of the heavier rocks. Movement of this type is believed to extend not deeper than 50 or 100 miles

into the earth. Below that depth rocks are believed to be of uniformly heavy material.

None of these theories may be right, or all may be right to some extent. It is known that gravity—the pull of the earth upon all materials which make it up—provides one great force causing the settling movement of rocks. Energy released from changes going on in the interior of the earth may provide another force causing surface movement.

What causes earthquakes? One of the immediate results of movement of the earth's crust is an earthquake. Usually an earthquake is caused by a sudden slipping of two rock surfaces against each other. There are many long cracks, called faults, in the surface of the earth. Some faults are hundreds of miles long. Even a slight slipping, as little as half an inch, of the rocks on one side of such a fault is enough to cause a severe earthquake. The shaking of the earth's surface usually lasts only a few seconds, but in that time houses may be shaken down and much other damage done.

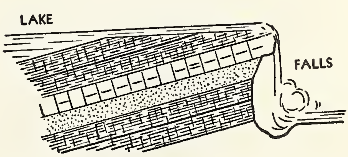
Earthquakes may result from slipping of rocks deep in the earth. It is possible to locate these earthquakes quite exactly by use of accurate recording instruments, although no evidence of slipping may be seen at the surface.

Earthquakes may cause landslides or other movement of soil. Sometimes underground streams which supply water to springs may be lost in deep cracks in the rock, and the springs become dry. Where people have laid water pipes, movement of the earth may break the pipes. Gas and oil pipes are sources of danger, for if they break, destructive fires may result. Cities in earthquake regions are now being made earthquake-proof. Pipes and bridges are built to withstand strains. Houses are made strong enough that they will not fall and injure people.

Near the ocean, tidal waves may be set up by sudden shifting of the earth's surface. A sudden high wave sweeping over the land may destroy docks, wreck boats, and drown people.

Do rock layers shift? An important effect of earth movement is the tilting of layers of rock. You know that materials settle from water to form rocks that are fairly level. Yet as a result of movement of the earth's surface, such layers of rock may be tilted until they stand on end, or they may be folded in the shape of a U, either right side up or inverted.

You know that water is constantly wearing away the land



Tilting of rock layers is a frequent cause of waterfalls. Where surface rock has been removed, it is easy to identify the layers originally deposited in a level position.

and carrying the materials into the ocean. You may wonder if some day all the land will be made level, so that the waves of the ocean can carry it away to leave only water on the earth. For millions of years processes of wearing away the land have been going on, yet the forces which cause land to rise have kept a fairly large part of the earth's surface as dry land. At present about one-fourth of the earth is above the sea.

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

The existence of limestone at a high elevation is evidence that the land has —1—. A valley filled with water is evidence that the land is —2—. Rocks composed of layers are usually formed under —3—, and are level when formed. Such rocks may be —4—, or —5— into a U shape. A sudden movement of the earth's surface causes —6—. It is believed that movement of the earth's surface does not extend more than —7— miles below the surface. The weight of surface rocks is changed by movement of materials by —8— water and by —9—.

3. How are mountains, plains, and plateaus produced?

The land surface of the earth is made up of many kinds of formations. These include hills, valleys, plains, plateaus, and mountains. It is not always clear just which of these formations you may be looking at. A wide valley may be a plain. Some hills are higher than some mountains. Actually, a formation of land is given a name which describes it in relation to its surroundings.

How are mountains formed? The usual volcanic mountain is made up of materials which come to the surface of the earth and escape through an opening to form a more or less cone-shaped peak. The materials of which such mountains are made are usually lava or ash. At the top of the volcano is a pit or opening called a crater. When a volcano is active, the crater is full of melted rock. When a volcano is quiet, the lava changes to solid rock, and there may be no evidences of activity at all. In the craters of other volcanic peaks, jets of steam may be found issuing from the rocks. Many of the most magnificent peaks in the United States are ancient volcanoes.

At depths of from 10 to 50 or 100 miles beneath the surface of the earth, pockets of melted rock form. This melted rock, called magma, is formed from rock already heated underground, when the pressure on it is released. Pressure may be released when the upper rocks are worn away, when they are folded, or when they are uplifted. We do not know just why some under-

ground rocks become very hot.

The melted rock flows slowly underground, melting or heating near-by rocks as it goes. These rock flows may not always reach the surface, but may still push surface rocks upward, causing them to form mountains. A mountain produced by the lifting force of melted rock may be made up of folded layers of surface rock. The folding caused by the pressure of upflowing melted rock may produce large mountain ranges, such as the Canadian Coast Range, the Sierra Nevadas, and the Green Mountains.

Other surface rocks may be caused to fold by the sidewise force of other, heavier rock layers. If you lay a piece of canvas on a smooth table top, you can make the middle of the canvas rise up in a hump or fold by pressing with your hands on its edges. It is believed that the Appalachian Mountains were originally formed by such a huge folding action.

A fault is a displacement of masses of rock caused by rocks slipping along a crack. If the displacement is great enough, part of the mass of rock may be elevated to make a mountain. One mass of rock may be moved so far that it is pushed up over the edge of the adjoining rocks. In such a case, one side of the mountain forms a gradual slope, while the other side forms an abrupt cliff. Such a formation is found in the Rocky Mountains of Colorado. The Wasatch Mountains of Utah were formed by erosion.

Mildred Vihstadt

Waves sometimes cut rocky shores into rugged cliffs. Where the water is fairly deep, large rocks along the shore are more common than fine particles of sand.

The process of faulting may be compared to the tilting of blocks of concrete in a sidewalk where it has been broken and made uneven. The block mountains actually resemble such concrete blocks in their slope and position.

Erosion, which is the wearing away of the land, may form mountains only when the land is already high above sea level. Bordering the Grand Canyon are mountains left between valleys worn by running water. They are remains of the high plateau through which the Colorado River has cut its way.

When melted rock has pushed its way upward through layers of softer sedimentary rock, the softer rock may be eroded, leaving behind ridges, domes, or mountains of igneous rocks. Sometimes these formations are of strange shapes and are called

Northern Pacific Railway

The Rocky Mountains have resulted from erosion of complex, folded rocks. Many of the ranges in these mountains are rugged.

by fanciful names, such as Devil's Towers.

Erosion occurs on all types of mountains. The huge folds which originally made up the Appalachian Mountains have been eroded, until today most of the ancient mountains are gone. There remain only comparatively low ridges formed by the edges of the harder layers of rock which were exposed by erosion. These ridges run roughly parallel to each other. Between them are troughlike valleys resulting from erosion of the softer layers of rock.

It is an interesting experience to climb to the top of a mountain formed by erosion of an ancient plateau. The region seems very rugged as one scrambles up the mountain from the valley. Then all at once it seems to become level as one looks across the distant mountaintops. One can see, in the small remaining land surfaces making up the tops of the mountains, the last remains of the original surface of the plateau.

How are plains and plateaus formed? Any region that is fairly flat and has only scattered hills is called a plain. The land may be gently rolling or may slope slightly. Plains are usually found at low altitudes. They may be formed by elevation of the ocean bottom or built up of sediment deposited from water. Some plains are formed by the filling, draining, or drying up of swamps and lakes.

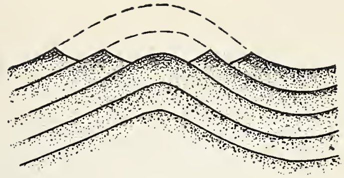
Some plains are formed by erosion of the land. The original, fairly level, surface of land is worn down as a river completes its lifework—first into series of ridges; then later into rolling hills and flat valleys. Eventually the surface may become level again.

Coastal plains are built up by materials washed from steep mountain slopes to the compara-

tively level ground along the shore. As the rushing water slows its speed, the materials it carries are deposited along the coast, forming a narrow plain.

A plain which occurs at a high altitude is called a plateau. In some plateaus the rock has been elevated directly from the sea bottom, and the layers are still level. The Colorado Plateau, through which the Colorado River has cut the Grand Canyon, has nearly level layers. In other plateaus the rock layers may be tilted sharply, with the rocks lying at an angle. The plateaus of the Appalachian region were formed by wearing down of folded rock layers.

Plateaus are worn down by erosion. In fact, it is on plateaus that rivers ordinarily begin their lifework. Many plateaus are deeply cut by the canyons of rivers. Examples of this cutting may be found in the valleys of the Snake and Columbia rivers in the West. On other plateaus the river has not begun its cutting action, and it flows on top of the plateau. At the edge of such a plateau there is likely to be a series of rapids or waterfalls. There is such a fall line along the edge of the Piedmont Plateau.



This diagram shows in a simple way the method by which the Appalachians were formed. The dotted lines represent the original folded rocks. The remaining ridges run roughly parallel to each other.

Where plateaus have been eroded away to some extent, interesting formations of rock may be left standing. These often take the form of a flat-topped hill called a mesa [mā′sȧ] or a butte [būt]. The top of a mesa is usually larger than that of a butte. In other regions erosion has progressed until remaining formations are hills or mountains.

Things to think about

Match the following subjects and predicates. Copy the sentences in your notebook.

Subjects

1. Melted rock
2. Volcanic peaks
3. Faulted mountains
4. Volcanic craters
5. Folded mountains
6. The end of all mountains
7. Coastal plains and the Great Plains
8. A plateau
9. Releasing pressure on hot rock

Predicates

A. may permit the rock to become melted.

B. may be formed by the sidewise pressure of near-by rock layers.

C. may exert sufficient force to cause folding of surface rocks.

D. are formed from materials washed down from mountains.

E. may have gradual slopes on one

side and steep cliffs on the other.
F. are more or less cone shaped.
G. is an elevated surface which is fairly level.
H. is reduction to a plain by erosion.
I. may be filled with bubbling, melted rock.

4. Where is water stored on the earth?

The storehouses of water are the lakes, the swamps, and the oceans. Of these the oceans are by far the largest. These bodies of water are very important to us for they not only store water but also regulate climate.

What is the ocean? The ocean is that great body of salty water that covers about three-fourths of the surface of the earth. Only the ridges of rock which form the continents are not covered by the ocean. Eventually all materials which are washed from the land either remain dissolved in the ocean waters, or settle to its bottom. If it were not for the constant elevation of land masses, the ocean would finally cover all the earth.

The ocean bottom has mountain-like peaks, deep valleys, underwater cliffs, and plains, much as the land has. The bottom of the ocean is generally smoother than the surface of the land, for it is not eroded by water. Irregular places are gradually filled by ooze settling from above. The water around the edges of continents is shallower than that in the main ocean. The materials washed from the land have settled there in the form of shelves. Along the Pacific coast of the United States this shelf is about 10 miles wide. On the Atlantic side, it is 60 to 80 miles wide. There are also ridges, as well as deep places, in the ocean. Some ridges may be high enough that their tops form islands. At its greatest depth the ocean is nearly seven miles deep.

How do ocean waters move? The water of the ocean has four movements. One of these is the tide. Another is the drift of surface water caused by the action of the wind. These drifts are five in number. There is one each in the North and South Atlantic, in the North and South Pacific, and one in the Indian Ocean. A third movement is a slow creep of cold water along the bottom from the poles to the equator, and a creep of surface water from the equator to the poles.

The most noticeable motion of the ocean is its waves. Waves are chiefly an up-and-down motion of water, but along beaches and the shoreline there is considerable sidewise movement as well. The waves dash against rock cliffs, breaking them down. The materials broken from the shore are carried out into the ocean as the waves return. Caves may be formed in cliffs. Waves wear down only that part of the cliff above the water line. That part below the water line remains as a bench. On this bench

New York State Museum

These glass models of sponges show a type of animal that lived in the sea perhaps 30 million years ago. When their skeletons are found in rocks on dry land, what is indicated?

materials worn from the shore usually form a beach.

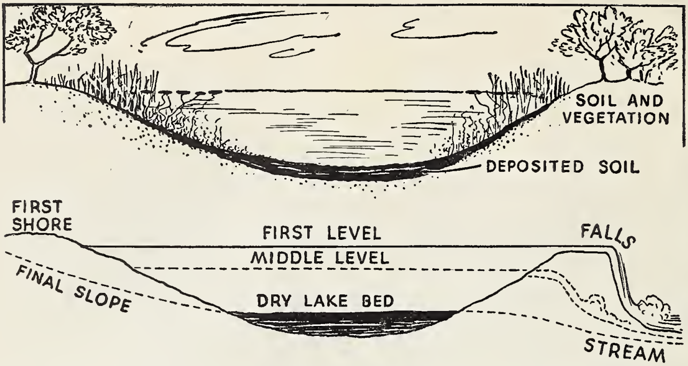
A beach may be of sand or gravel, depending on the hardness of the rock, and the length of time since its formation. Waves break on the beach, rolling and grinding the materials. The water of the wave flows back as a current, carrying some of the broken material with it. These materials are sometimes deposited far out in the water in the form of bars, hooks, or spits. Such formations are not permanent.

Waves are not entirely responsible for the shape of the shore. Where the land is sinking the shore is likely to be steep. Where land is rising it is likely to be gradually sloping. Materials washed into the ocean by running water form swamps, deltas, and muddy regions. Yet waves do gradually re-work these materials.

How were lakes formed? Lakes are formed in two ways: Low places in the earth's surface may be filled with water or some obstruction may block a stream to cause formation of a lake.

Many lakes are found in the depressions scooped out by the huge glacier which about 25,000 years ago covered the northern United States. As the ice melted, the resulting water filled the low places. Glaciers on mountains may scoop deep holes in the rock, which fill when the glacier is melted.

There are low places in deserts where there has never been sufficient water to form a drainage system. When an occasional rain



Some lakes disappear because they are filled in by soil and vegetation. Others disappear because the streams which drain them wear their channels deeper until all the water escapes.

falls, temporary lakes fill these low places, only to disappear as the water evaporates. Sometimes enough water falls to form a permanent lake. Desert lakes are often salty.

Streams have been dammed in the past by glaciers blocking their channels, either by forcing a dam of earth across the valley or by the ice itself blocking the channel. There are many of these lakes formed behind glacier-built dams in the mountains.

Among the most ambitious of all pond builders are the beavers which build dams across streams to provide themselves with the environment they need for a home. Beavers cut trees for the framework of the dam, use branches and twigs to fill in smaller openings, and cover the whole structure with earth and mud. Beaver ponds are of great importance in regulating flow of water and in providing still places in rivers.

Why must most lakes disappear? Lakes disappear either because they are filled up or because they are drained. Filling of lakes occurs wherever sediment-bearing streams flow into them. At the mouth of the stream a delta may form which gradually builds its way into the lake. Lake Geneva in Switzerland, originally 47 miles long, has been decreased in length seven miles by this filling process.

Vegetation grows out from the shores when lakes become sufficiently shallow. Plant growth can completely cover a lake, and form a bog. Such bogs may be so thin that people may fall through and lose their lives in the oozy water beneath.

As rivers that flow out of lakes cut their channels deeper, lakes are drained. If there is no natural outlet, the overflow from the lake during high water will start one. Once started, each successive period of high water en-

larges the channel until the stream flows continually and the lake is drained. A lake formed by a glacier blocking a valley is drained when the ice melts.

How are swamps formed? In a swamp the water table is at the surface of the ground. There may be areas of open water in swamps, but usually the surface consists of soil and vegetation.

Swamps result when a lake is filled, but before all the water has been displaced with soil or rock. Swamps also occur along the margins of lakes and rivers, where marsh plants stop the action of waves and currents, permitting soil to be deposited. Most shallow lakes have at least a small margin of swampy land.

There are huge swamps in the valleys of old rivers. When the valley has been worn so flat that there is little slope, the soil becomes completely saturated with water over large areas. The river winds its way over the flat land, frequently cutting itself a new channel. The old channel often remains as a lake, surrounded by swampy land. These river-formed lakes often resemble an oxbow in shape. They are cut off from the main channel of the river by ridges of material deposited by the sluggish river along its banks. Such lakes are found along the lower Mississippi River.

Paul's Photos

The lakes along the lower Mississippi frequently blend into swamps along their shores.

There are also salt-water swamps along the ocean, which build soil in the same way that lake swamps do. The plants that grow in salt water, however, are quite different from those which grow in fresh water. After deposits in coastal swamps have changed to stone, it is possible to identify the stone from traces of plant material in it. Thus the edges of ancient seas have been located by study of rocks.

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

The great circular movements of ocean water are called —1—. —2— are chiefly an up-and-down movement of water. On a wave-cut shore —3— is usually found above the water line and —4— below it. The bottom of the ocean is —5— regular than the surface of the land. Lakes are formed where —6— fill with water or where a —7— is blocked by an obstruction. Lakes disappear either because they are —8— or —9—. In a swamp the —10— is at the surface of the ground.

5. How does running water level the earth's surface?

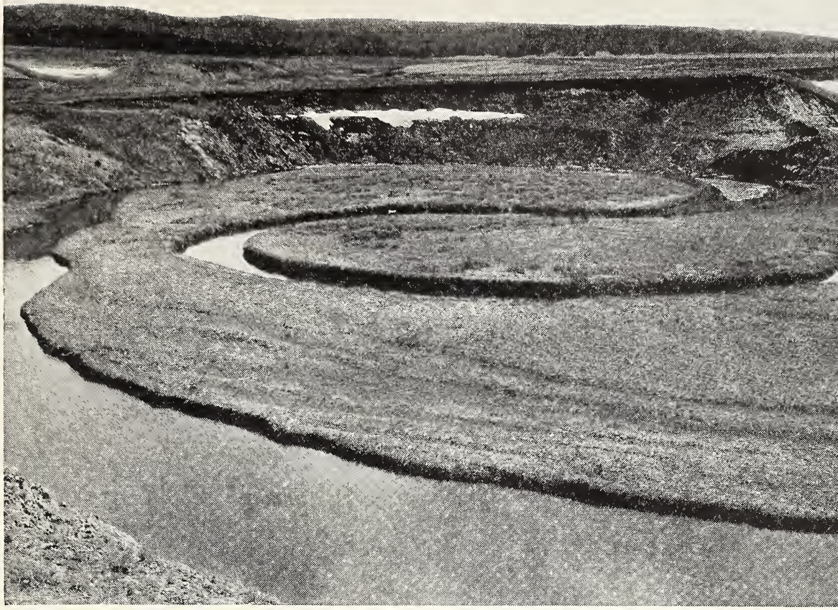
Erosion is the chief force which reduces the height of mountains. Rocks are gradually weathered, and the particles loosened by weathering are carried to lower levels of the land or to the ocean. This work of erosion is largely accomplished by running water.

Why are there streams? On every part of the earth's surface some rain or snow falls. In the driest place in the United States, Death Valley, there are about two inches of rainfall per year, while in the wettest regions the rainfall may exceed 200 inches. Some water that falls may lie on the ground as ice or snow, some may evaporate into the air, and some may soak into the ground. A large part of the water runs immediately from the surface on which it falls and forms small streams. The force which moves water downhill is gravity.

Since no part of the earth's surface is entirely level and smooth, running water encounters little difficulty in starting its journey to the ocean. The moving water, which is called runoff, may first flow as a thin sheet, if the ground is fairly smooth and level; or it may immediately find its way to a tiny, trickling stream. The small streams eventually unite to form creeks or brooks which, in turn, combine to form rivers. In many regions rivers combine to form the huge river systems, such as those of the Mississippi, the Columbia, and the Colorado.

What is the lifework of a river? The lifework of a river is to drain and wear away the land over which it flows. When a river begins its work on a region that has not been previously eroded—for example, a recently elevated plain—there are no valleys in which the stream may flow. It must find its way from one low place to a lower one as best it can. As a result, there are many ponds and small lakes and many waterfalls where the water is forced to tumble over shelves and ridges of rock which bar its way to the ocean. The first work of a river is to cut itself a channel in which it can flow. As the river continues its work, the sides of the valley are washed down by smaller streams and sheets of runoff water. The running water carves openings through the ridges of rocks which cause falls to form. As the work of cutting and widening its valley progresses, the stream drains the land more rapidly and completely. Lakes and waterfalls disappear.

Finally the valley becomes so wide that it is almost level. The bottom of the valley has been cut down to a height but a short distance above sea level. The drainage becomes more sluggish as the slope decreases. If there is no further elevation of the land, the



U. S. Department of the Interior

When a river fills its valley it forms a plain. Then it may wander and curve on the plain. If at a later date it cuts its channel deeper, the river may remain in its curved course.

valley may eventually become a flat, marshy plain, with a slow-moving river winding its way between banks scarcely higher than the surface of the water.

It is unlikely that many rivers will have time to complete their lifework. The surface of the earth is in such constant motion that no large area is likely to remain long enough at one elevation to be completely worn away by one river system. The land near the mouth of the river may be elevated, forcing the river to cut itself a new channel or even to flow backward. The changing slope of the land may cause the river to change its course. The valley may sink into the ocean long before the river has worn the land down to sea level. One river may cut its way into the valley of another, stealing its water and leaving it almost dry.

How does water cause erosion? Water erodes the land in three ways: by the force of its fall, by dissolving the materials with which it comes into contact, and by grinding action (abrasion) when rocks are rubbed against each other. The stream carries away the materials which it loosens from the land.

The force of the river's fall depends upon the steepness of the slope and upon the amount of water in the river. If you have ever turned on a faucet where

the water strikes the ground directly, you know that in a short time a hole is washed out. But running water has little ability to loosen solid rock. Most rock carried by streams is first loosened by weathering, which results when ice, air, heat and cold, plants and animals, and other forces break and crumble the rocks. It is where a loose soil has been formed that rivers can erode the land most rapidly.

Where there is an abundance of loose material to be carried by a river, it may pick up an enormous load. A stream flowing at a speed of one mile per hour may carry mud and roll small pebbles along the bottom. A stream flowing two miles an hour will carry much more mud and may roll pebbles more than an inch in diameter along the bottom. Doubling the speed of water increases its ability to carry materials more than you would expect. If a stream increases in speed from one to two miles an hour, its ability to carry solids increases 64 times. Rapid mountain streams can at flood time move boulders weighing many tons and wash out huge canyons within a few hours.

The movement of dissolved materials is greater than seems possible. Every year the rivers of the earth carry about three billion tons of dissolved materials into the ocean, where it remains to add to the salt and other mineral matter which gives ocean water its bitter taste. Erosion by solution carries away the most valuable plant food in the soil, for plants depend for mineral food upon dissolved chemicals from the soil.

The loose pebbles which roll and bump their way along the stream bottom not only wear each other but also cut into the stones buried in the bottom. The rough pieces of rock become rounded pebbles, and the large stones over which the stream flows become smooth. The particles broken off are carried away by the stream.

The combined forces of erosion cause the river to enlarge its valley in two ways. The valley constantly becomes deeper, until it finally reaches or approaches sea level. It also becomes wider, as the river carries away materials washed down from the valley sides and as the river carves its way into its bank.

How extensive is the work of river erosion? In any one year the amount of soil and rock eroded from a continent may be only a small fraction of an inch deep. But erosion, continued year after year, levels mountains, destroys farm lands, and changes the weight of materials on various parts of the earth's surface. Erosion indirectly may be one of the causes of earthquakes, which result when the balance of forces acting upon the earth's surface is upset.

It is estimated that the lower third or fourth of the Mississippi Valley is largely built of materials which have been washed from the upper valleys, particu-

larly from the east slope of the Rocky Mountains. Off the shore of every continent there is a shelf of material built from rock and soil carried into the sea by running water.

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

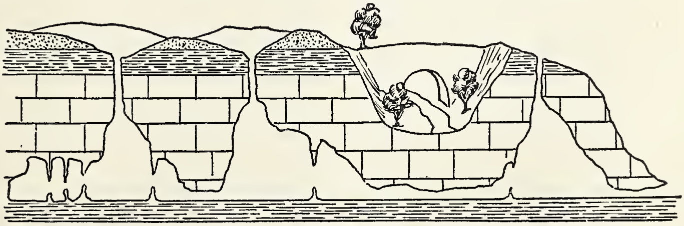
The force which levels the earth's surface is —1— acting to move —2— downhill. The lifework of a river is to —3— and —4— the land. —5— are caused when running water encounters layers of hard rocks through which it cannot cut a channel. Streams move materials which have been loosened by the forces of —6—. Doubling the speed of water increases its ability to carry materials —7— times. When a river has completed its lifework, the land becomes a marshy —8—. The land is —9— drained when a river is beginning its lifework.

Note

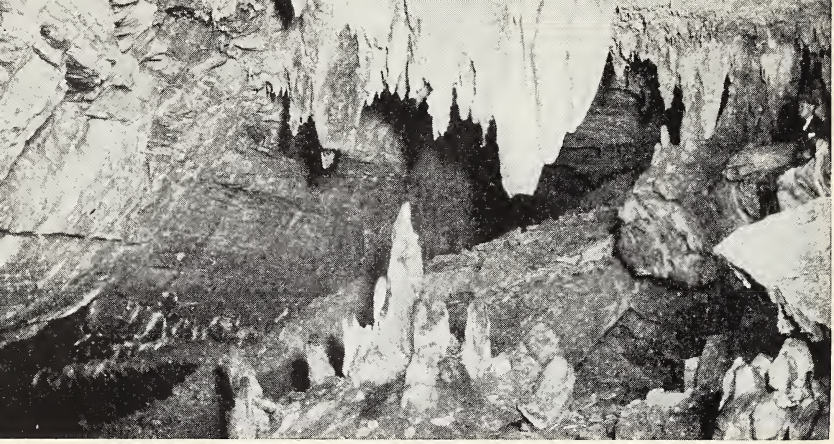
6. How does ground water change the earth's surface?

Only about one-third of the rainfall is carried off by surface streams. The rest either is evaporated or is absorbed by the ground. The amount that soaks into the ground depends upon the type of soil and rock upon which the water falls. If the surface is porous [full of spaces], a high percentage of the water will be absorbed. In certain formations of sand and of limestone, no water may run off at all, but all will sink into the ground. Igneous and metamorphic rocks absorb practically no water. Areas covered with vegetation retain much more water than do areas which are cultivated or which are bare of vegetation.

Where is ground water found? Some water which soaks into the ground moistens the particles of soil through which it runs. After the particles of soil have taken in all the water they can hold, the rest flows down into the porous rocks until it comes to a layer through which it cannot pass. Such a layer of rock is said to be



These formations are typical of a limestone region. Three sinks carry water underground. The cave has three large rooms. Can you see the natural bridge? Where are the stalactites and stalagmites?



U. S. Geological Survey

When water dissolves minerals, these minerals are deposited as the water evaporates or changes in some other way. These stalactites above and stalagmites below are commonly found in limestone caves.

impervious [ĭm-pûr′vĭ-*ŭ*s, without pores]. Water gradually accumulates in the spaces of the porous rock. If the layer of impervious rock is shaped like a basin, the underground basin holds water somewhat as a lake does. If the impervious layer slopes, the water slowly flows along its surface until it comes to some opening from which it can escape. All such water held beneath the surface of the earth is called ground water.

Ground water is widely distributed, except in deserts. Even in deserts water may be found deep underground, where it has flowed through porous layers of rock from distant mountains. There may be a few regions where the rock is impervious from the surface and all the way down. Water has been found in wells drilled to a depth of two miles below the earth's surface.

How does ground water cause soil movement? On steep slopes ground water may soften and loosen the soil after heavy rains. This loose soil then slides downhill because of gravity. The amount of damage to roads and railroads caused by landslides is important. In cold regions the ground water freezes to considerable depth. In the arctic this frost in the ground is permanent, and at places extends to a depth of 700 feet. One-fifth of the land of the earth contains permanently frozen ice. The melting and freezing of ground water causes movement, tilting, and settling of the land. In cold states roads are frequently broken by the action of frost in the ground. Basement walls may be cracked or houses caused to settle by frost.

What materials does ground water dissolve? When water flows underground, it dissolves

many materials. In limestone regions the rock is easily dissolved, particularly if the water flows from areas on which plants grow. Iron compounds are also easily dissolved in water, and frequently we find reddish-brown stains left by dripping water. Common salt and other minerals dissolve readily in water.

What formations are made by ground water? In regions where the underground rock is limestone, water dissolves its way into cracks in the rock. The cracks are enlarged until funnel-shaped holes are formed. The surface water drains into these holes, which are called sinks, and either flows away through connecting cracks underground or remains to form small ponds or lakes. The water which flows through underground cracks in the rock usually appears at the surface at some lower level as a spring.

Water flowing through the cracks enlarges them. More water seeps in from connecting cracks, which are in turn enlarged. Thus caves are formed. If the cave is near the surface, the ceiling may fall down, exposing the underground stream to view. If part of the roof of the cave remains, it may form a natural bridge.

There are many natural bridges in the United States. The largest is found near Lexington, Virginia. Its arch is more than 200 feet above the valley floor. This bridge may have been formed by surface water seeping into a crack across the bed of a stream which was located on a level with the top of the arch. As the water enlarged the crack, the water finally came out through a hole under the present arch. In time the hole became big enough to carry all the water formerly carried by the stream on the surface.

There are many magnificent caverns formed by water dissolving limestone rock. Two of the best known are Mammoth Cave of Kentucky and the Carlsbad Caverns of New Mexico.

In Yellowstone National Park the ground water has made many strange terraces and mounds composed of materials brought by hot water from underground.

Why does ground water deposit materials? There are several reasons why water may deposit materials which it has dissolved. If the water was hot when the materials were dissolved, and then cooled, some of the material will be deposited. Cold water holds less of most dissolved materials than does hot water. If water contains carbon dioxide when the materials are dissolved, and the carbon dioxide escapes, some materials will be deposited. The water may dissolve two kinds of chemicals which act on each other to form new chemicals which will not dissolve. Tiny plants and animals may take materials from the water and deposit them. Part of the water may evaporate, causing materials to be deposited.

What materials are deposited by water? Almost everyone is fa-

miliar with the beautiful columns of rocks deposited in caves by water dripping from the cavern roofs. The water dripping from above forms long, icicle-like stone formations. At the bottom, the dripping water forms a cone-shaped mass of rock. The two may eventually join to form a complete column. The formations which resemble icicles are called stalactites [stȧ·lăk′tīt]; those which are formed on the ground are called stalagmites [stȧ·lăg′mīt].

Agates, attractive banded stones collected by many people, are deposited from water. The materials which make up these rocks are frequently deposited in layers inside cavities in other rocks. Each layer of material contains slightly different minerals from the one before, making the banded appearance.

The deposits of rock in Yellowstone National Park are only slightly less famous than the hot springs and geysers which bring the water that leaves the deposits behind.

The most important deposits formed underground are the minerals containing silver, lead, zinc, and other valuable metals. Most of these metals are found combined with other elements in compounds that dissolve readily, especially in hot water. At considerable depths in the earth the temperature of the water may approach 1000 degrees F. Water so hot dissolves its way through rocks, taking from them the minerals, and finds its way into some convenient crack. There the water is forced by the pressure of the rocks to flow upward. As it flows upward, it cools and deposits its load of minerals in cracks. Such a crack in a rock filled with a mineral is called a vein. The underground water does two extremely valuable things in forming mineral deposits. First, it dissolves from the rocks the scattered minerals, and concentrates [increases in strength] them. Second, it brings these minerals nearer the surface of the earth where we can find them.

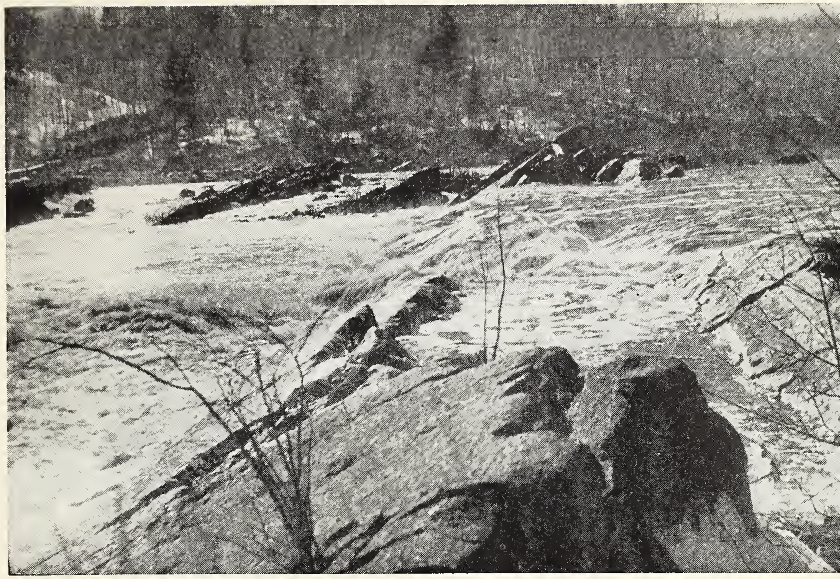
DEMONSTRATION: HOW DOES WATER DISSOLVE MINERALS FROM THE SOIL?

What to use: Soil, watch glass, beaker, ring stand, burner.

What do do: Stir the soil in a small amount of distilled water, and let the water become clean either by settling or by filtering it. Put three drops of water on the watch glass, and set it over the beaker, one-third full of water. Put the beaker on the ring stand and boil the water until the water in the watch glass evaporates. Dry the bottom of the watch glass, and examine it carefully. Similarly test tap water.

What was observed: What did you observe on the watch glass? Where does mineral come from? Where does the salt of the ocean come from?

What was learned: Does water dissolve enough material from soil to reduce it in value? Explain.



Resistant layers of rock slow down the process of erosion and cause the formation of waterfalls. The river is gradually cutting a notch in the tilted layer of rock which dams its progress.

Things to think about

Copy the following sentences in your notebook. Select the correct ending for each sentence.

1. Ground water (*a*) wets soil particles (*b*) is held in porous rocks (*c*) runs off the surface (*d*) evaporates.
2. Ground water (*a*) dissolves many materials (*b*) is usually hot (*c*) dissolves granite rapidly.
3. Impervious rocks (*a*) prevent ground water from passing through (*b*) absorb ground water (*c*) are readily dissolved.
4. Caves are formed by the action of ground water on (*a*) granite (*b*) carbon dioxide (*c*) limestone (*d*) soil minerals.
5. Minerals are deposited from ground water because (*a*) they are heavy (*b*) the water may be cooled (*c*) the water boils.
6. Reddish-brown stains left by water indicates the presence of (*a*) agate (*b*) lime (*c*) iron.
7. Mineral veins are formed when (*a*) hot water dissolves minerals underground (*b*) minerals fill caves (*c*) water cools in cracks (*d*) geysers bring water to the surface.
8. Porous rocks are (*a*) granite (*b*) obsidian (*c*) basalt (*d*) limestone (*e*) sandstone.

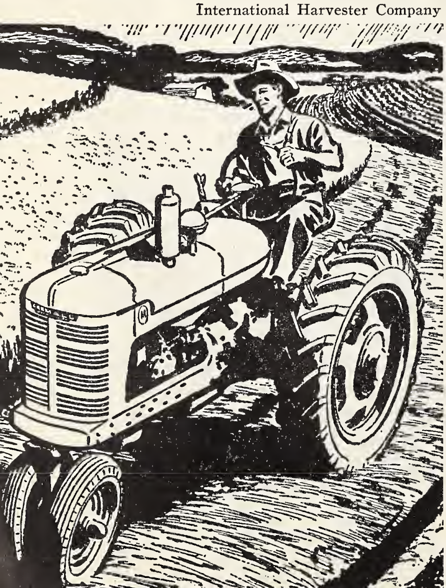
7. How can we prevent soil erosion?

There is nothing we can do to stop such great changes as the formation of mountains or the rising and sinking of the coast lines. These changes require millions of years. An immediate problem we must solve, however, is the erosion of land. If we do not prevent erosion we may sometime have no soil left for growth of food. Since people first came to the United States they have caused soil erosion to such an extent that one-fifth of the land once used for farming is now worthless for that purpose. Much more soil has become almost worthless for farming.

There are two important parts to the problem. One is to prevent the erosion of soil by ordinary movement of wind and water. The other is flood control.

Only recently have farmers learned that soil erosion can be reduced by cultivating around hills with all the furrows on the same level.

International Harvester Company



How can soil erosion be prevented? In a perfectly flat field water cannot erode soil very much. As the slope of the land increases and the speed of running water increases, the amount of soil lost also increases. Even in localities where there is not enough rainfall to cause much erosion, the wind can erode the dry soil. Thus the problem of soil erosion is nation wide.

There is only one way to keep soil from washing from fairly steep land. That is to keep it constantly covered with some kind of plant growth. Where the slope is very steep and the soil is thin, trees and bushes give the best protection. If the soil is too thin for farm crops, it is better for it to be covered with weeds than to be bare. On any bare sloping ground a small valley, called a gully, may start and may increase in size.

Where the land is fairly dry there are only a few kinds of trees and shrubs that will grow. Even in the desert a few kinds of shrubs and grass will grow. Three great dangers threaten dry lands. One is the farmer who plows land which will not grow crops because of lack of moisture, and thus destroys the plant cover. Another is the irresponsible stock grower who lets cattle and sheep eat all of the grass, parts of which should be left to protect the land. A third danger is grass fires.

Milwaukee Road

By planting crops in strips on hillsides, erosion can be checked.

Deserts are often badly eroded by water. Desert rains usually come in short, violent showers. Because there is little cover on the ground, the water runs off immediately, causing floods and cutting deep gullies in the ground. Soil washed into the rivers makes the water muddy. Many cities of the west depend upon the water from rivers starting in mountains and flowing through deserts.

The soil carried in muddy rivers kills fish and fills spaces behind dams. It is estimated that by the year 2050 Lake Mead behind Hoover dam will be filled with mud and will store no more water. Silt also covers valuable farm lands and ruins them.

Can erosion be controlled in fields? In no other place is erosion so rapid as in the soft soil of sloping cultivated fields. Yet even in fields erosion can be controlled. Two chief methods of erosion control are employed. One method is called contour farming. Cultivation along contour lines [lines through points of equal elevation] causes all ridges and furrows to be formed across the slope. In this position they act as dams that check the flow of water. The other method is called strip cropping. Crops are planted in strips along contour lines. At the top of the hill and on steeper slopes strips of plants which form a tough sod are grown. Along the more gradual slopes fields in the form of strips are cultivated on contour lines. The strips of sod hold and absorb the water, so that it does

Minneapolis Moline

Harvesters may leave straw scattered on the ground. When the ground is plowed, the straw improves the soil. It also protects the soil from erosion.

not have enough force to wash away soil in the cultivated strips. These two methods are of great value in controlling field erosion.

Can floods be prevented? It is highly desirable to control or prevent floods. Along the Missouri, the Mississippi, the Columbia, and the Ohio rivers, and many smaller streams, floods do great damage. The amount of permanent damage to soil can hardly be estimated. Towns and farm buildings are washed away. Farm crops are ruined. Trees are uprooted. Roads and bridges may be damaged beyond use or completely washed away. Even where flooded buildings remain standing, they are coated with mud and severely damaged. And worst of all, many people drown in floods.

To control floods the first thing to be done is to slow the flow of water where it starts—from farm lands, from pastures, from the forests, and from waste lands. On all of these places a good cover of vegetation is essential.

Next, as much water as possible should be stored near its source. Beavers should be placed in wooded, headwater regions. On small creeks dams of stone and wood may be built which will form ponds and small lakes. Some of this water will seep into the ground, and some will run off slowly. As small streams join and form rivers, the rivers can be held in check by larger dams. On the great rivers such as the Missouri, the Tennessee, the Columbia, and the Colorado the famous dams form the last defense against floods. It is not possible to build storage dams along the lower Mississippi, because here the land is so flat that the lakes would spread for miles and still not hold much water. Dams are most economically built in

deep, narrow canyons where there is space for a deep lake behind the dam.

The principle of flood control is to hold as much water on the land as possible, then to store as much of the run-off as possible for future use and to spread it over a large area of lake surface. Even with the best of planning, occasional floods may occur, but the damage done will be greatly lessened.

Can waste land be reclaimed? If a fifth of the farm land of the United States and a large share of pasture land is ruined, what can be done with it? Should we permit it to continue to wash into lakes and rivers, ruining water supplies and creating sources of deadly floods?

It is not easy to reclaim land. For example, several attempts to re-seed desert land with grass met with failure. Seeds dropped on the land did not grow. In a new method, successful growth was started when seeds were used which were coated with a small ball of clay mud containing fertilizer. These balls were dried and scattered from an airplane over the desert. The clay and fertilizer gave the seed the needed plant food to start growth.

To reclaim forest land it is sometimes necessary to plant trees by hand, one at a time, over miles of territory. The small trees are grown in nurseries, which is expensive. Scattering tree seeds from an airplane has been successful under the right conditions.

No matter how expensive reclaiming land may be, it must be done. Soil and water are basic necessities.

What are by-products of flood control? As floodwaters are stored, lakes are formed which provide boating, swimming, fishing, and attractive scenery. Wildlife gains in number around these lakes. The normal flow of water in the river can be used for electric power, thus conserving our coal supplies and making our work easier. Storage of floodwater for summer irrigation makes farming possible in dry regions. The lands are richer, the grasses greener, the forests cooler and better where floods are controlled. The green, beautiful land of which we all dream depends upon saving soil and water.

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

In moist climates most erosion is by —1—. In dry climates erosion is chiefly by —2— in dry seasons, and occasionally by —3—. The most valuable kind of plant to cover desert lands is —4—. Steep slopes should generally be covered by —5—. To hold water on the soil a cover of some kind of —6— is most useful. Soil washed into streams fills spaces behind —7—, and reduces water storage. Dams are best built in deep, narrow —8—. On small streams many small dams are used to —9— water.

A review of the chapter

Because gravity causes the various regions of the earth's surface to come to a balance, many changes in the level of the surface occur as materials are eroded from one surface and deposited on another. The run-off and ground water are the principal agents of erosion, which tend to reduce elevated areas to plains at lower levels. The work of erosion and the movements of ocean water are produced by the force of gravity and the energy of the sun. Proof that there have been many surface changes is found in the composition and position of the rocks, and in the various formations which make up the different types of landscapes. It is important that erosion of soil be controlled as completely as possible. Proper methods of cultivation and flood control, and reclamation of waste lands are now necessary.

Word list for study

Be sure that you can pronounce, spell, define, and use in a sentence every word in this list. Each of these words has been defined or explained and used in this chapter.

igneous	bog	erosion	granite
magma	stalactite	beach	plateau
conglomerate	contour line	impervious	lava
earthquake	sedimentary	stalagmite	butte
fault	basalt	silt	bench
drift	limestone	metamorphic	porous
			mineral

An exercise in thinking

Below are two groups of sentences. The first group contains principles, which are large general ideas. Each sentence in the second group contains an idea related in some way to one of the principles in the first group. Write the numbers from 1 to 34 on a piece of paper or in your notebook. Find the principle which best explains the idea in the second list. Then after the number on your paper write the letter before the related principle.

List of principles

A. Constant changes in pressure of the rocks cause the surface of the earth to be raised and lowered.

B. The lifework of a river is to drain and wear away the land.

C. Ground water changes the earth's surface by dissolving minerals and depositing them.

D. Layers of rock generally occur in the earth's surface in the order in which they were deposited.

E. Igneous rocks are formed by cooling of melted materials.

F. Sedimentary rocks are com-

posed of materials deposited from water or wind.

G. Metamorphic rocks have been changed in form by heat, pressure, or water.

H. The erosive action of moving water depends chiefly upon use of rock materials for cutting tools.

List of related ideas

1. Limestone is soluble in water containing carbon dioxide.
2. A river valley increases in length by cutting the channel back toward the source.
3. Many iron ores have been separated from the rocks by water.
4. Many mountains are formed by erosion by running water.
5. Earthquakes occur at times along the Pacific Coast.
6. Limestone is formed from the shells and skeletons of sea animals.
7. Presence of limestone rock on surface is proof that the land has been raised.
8. The Appalachian Mountains were formed by folding of rocks.
9. The first valleys formed by a river are V-shaped.
10. Dikes are found separating layers of rocks of other types.
11. Many mountains were once active volcanoes.
12. Limestone caves are always formed by solution.
13. Limestone changes to marble when enough heat and pressure are exerted on it.
14. Rocks are worn slowly along the shore where the water is deep.
15. Minerals occur in veins in which water has cooled.
16. Conglomerate is a rock composed of cemented pebbles.
17. Sea caves are formed by undermining solid rocks.
18. The terraces of Yellowstone National Park are built by hot water.
19. Slate may get its black color from vegetation present in the clay materials from which it was formed.
20. Much of the fertility of the soil is lost to the ocean.
21. Deposits of sand along the continental shelf form coarse rocks.
22. Beaches occur where a bench has previously been formed.
23. In many places there is little surface drainage because the water flows into sinks.
24. The first rocks forming the bottom of the ocean were basalt.
25. Study of rock layers in cliffs shows the history of the region.
26. The Hudson Valley extends beneath the water on the ocean bottom.
27. When lava flows beneath rocks and heats them, they often change in form.
28. The size of the crystal in some rocks is an indication of the rate of cooling.
29. Pebbles along the beach are always rounded.
30. The fine-grained rocks of the ocean bottom are composed of shells of tiny animals and dust carried by the wind.
31. Beaches are sometimes found on high mountains.
32. If gravel is found above a layer of sandstone, the land has probably been elevated there.
33. A layer of sedimentary rock at the surface in one region may be buried far beneath the surface in another place.
34. Lakes tend to disappear as the level of the land is lowered by erosion.

Seattle Chamber of Commerce

The action of waves produced this curious formation, called Elephant Rock. Can you see the elephant?

The crater of a geyser is composed of materials dissolved by hot water underground and deposited when the water cooled. The geyser was full of boiling water when the picture was taken.

Arta Verity

Sand dunes along the seacoast often are covered with vegetation, because quick-growing plants take root in the moist sand. The plants slow down the blowing sand so that such mounds of sand stay in one place for some time.

Some things to explain

1. What happens to limestone removed from caves by water?
2. Why are there so many kinds of rocks?
3. Why is a creek bed a better place than a plowed field to hunt for rock specimens?
4. Why are there no caves in regions composed of granite rock?
5. Why do farmers living on hills have a more difficult time to keep the soil fertile than do those living in valleys?
6. What is the difference between a crystal and a grain in rocks?

Some good books to read

Bretz, R., *How the Earth Is Changing*
Fenton, C. L. and Fenton, M. A., *Land We Live On*
Fenton, C. L., *Our Amazing Earth*
Lucas, J. M., *Earth Changes*
Reed, W. M., *Earth for Sam*
Reed, W. M. and Bronson, W. S., *Sea for Sam*
Van Dersal, W. R. and Graham, E. H., *The Land Renewed*
Williams, *Stories in the Rocks*

Industrial Rayon Corporation

UNIT FOUR

CONSUMING WISELY

Sharon was busy arranging her apparatus as the class settled into place. She began, "I am going to show you how to test the strength of cloth."

She had a strip of cloth an inch wide with one end clamped to a board and the other end between two blocks of wood.

She said, "Arthur, will you help me with this experiment? The test is to see how much pull is required to break the cloth. We will pull on this spring balance, using it to pull the clamp on the loose end of the cloth. I want you to pull on the balance while I watch it and hold the board steady."

Arthur took his place, and arranged the balance so that he could pull on the clamp with it.

Sharon directed, "Now pull slowly so that I can read the pointer as you pull. I think we can break this strip easily."

Arthur pulled steadily. As the spring of the balance was extended almost to the end, the cloth suddenly gave way, and the clamp fell to the table.

Sharon reported the results. "This was a thin piece of cloth. It broke with a pull of only 22 pounds. Some cloth is much stronger than this sample. It may not break with a pull of less than two to four times this amount. Breaking strength is one of the best tests of cloth.

CHAPTER

7

Learning to Buy Wisely

For hundreds and perhaps thousands of years people have been trying to discover why some people want to buy many things, while others can be satisfied with very few things. Most people, at all times, have had the problem of making a small amount of money buy the necessities of life.

As long as people buy and as long as there are people who sell, it will be necessary for each group to study the problem of wise buying. You will always be a consumer—one who uses things. And there is a good chance that you will be a person who sells. People who sell things make up one of the largest occupational groups in the United States. Many of these people engaged in selling do their jobs poorly because of lack of knowledge of goods, of correct methods of selling, and of reasons why people buy.

It is to be hoped that someday we can give up the old Roman motto, "Let the buyer beware." When we perfect all products offered for sale, when all of those who sell do so fairly and with full understanding of the value of their goods, perhaps the buyer will have less reason to beware than he once did. But even with perfect goods and with absolutely honest merchants, the buyer would still have to protect his own interests. There are so many things he might buy that he could not possibly need, use, or pay for all of them. The only thing to do is to learn to buy wisely.

Some activities to do

1. Conduct an honest blindfold test in class. Decide on some products to compare, such as butter and oleomargarine, regular and instant coffee, or cane and beet sugar. Let each member of the class in turn be blindfolded, and try to determine which is which of the products tested. Be absolutely clean in handling food. Scrub your hands, use clean dishes or waxed paper for the food. Unless 75 per cent choose correctly, results might be due to guessing. If some pupil is especially

sure he knows the difference, let him repeat the test 15 times.

2. Obtain three samples of different expensive perfumes, and three of inexpensive perfumes. Obtain six small pieces of blotting paper, and write numbers on the back from 1 to 6. Let one person put two drops of one of the samples on each blotter, keeping a secret record of the kind put on each numbered blotter. Let several members of the class smell the blotters and make a secret report of preferences. Then compare preferences with cost of the perfumes. Will your results be typical of all people? Do boys and girls prefer different perfumes?

3. Obtain a "flasher" lamp and demonstrate it to the class.

4. Have a contest to find the most ridiculous or unintentionally amusing advertisement. Many statements in advertising are so far removed from common sense and fact that they should seem funny to you.

5. Have a similar contest to find the silliest trade-marked name of a product.

6. Read the advertising in two newspapers and two magazines to see how many really sound facts you can find about the product advertised. Underline them in red. What is most of the writing in our modern advertisements composed of? Listen to a radio program to see if it gives you real information. What did you find out?

7. Write a play called "Alice in Blunderland," telling of the adventures of a girl who always bought things she did not need, and who never had things she did need. Produce it as a school auditorium program.

8. Find five advertisements in magazines directed at each of the four urges or feelings which cause us to buy.

Kenneth M. Wright

How does this picture make you feel? If it makes you feel that hunting is manly, it would be effective in selling. If you feel that it is cruel to kill the ducks, it would not be.

Some subjects for reports

1. The services of Consumers' Research, Inc.

2. The cost of selling and retail profits in different kinds of stores

3. How comparative tests of various goods are made

4. Some strange styles of present and past

5. The development of some common article and its final acceptance

6. What makes costs of articles vary from year to year

1. Why do we want things?

It may seem foolish to ask why people buy the things they do, for it is clear that we buy to satisfy our wants. Yet it is not an easy problem to know why we have certain wants. There is a difference between a want and a need. We need food, clothing, and shelter in order to live and be healthy. We need some things in order to be accepted by the social group in which we live. We want other things to satisfy desires which we cannot easily explain. The desire to have permanent waves, malted milks, footballs, chewing gum, and portable radios is not based upon any actual need.

Do we have wants not based upon need? Psychologists [sī·kŏl′ō·jĭst] are scientists who study the behavior of people and of other living things. Psychologists have learned that people often act to satisfy desires that they themselves cannot easily explain, and may not know they possess. These scientists have also learned that after people satisfy their hunger and other bodily needs, they have four strong basic desires which cause them to act. The first is the desire to be strong and dominant and manly or masculine—even girls have it. The second is the desire to be adequate—that is, capable of getting along in a social group and making a good impression on others. The third is the desire for love and romance felt by everyone except very young children. The fourth desire is to remain alive—to escape pain and suffering and to avoid death.

These four desires are natural urges and are not directly related to buying. Even if there were nothing offered for sale, the urges would still exist. Primitive people who have never seen a store or listened to a radio advertising program are just as anxious as we are to satisfy these four desires.

When we satisfy one of these desires, we do so because of a

The desire to be manly should cause a boy to take part in healthful athletic activities. When the desire to be manly is used to advertise tobacco or liquor, it will not appeal to the really manly boy.

Eugene Rosing

Brown

Many pictures used in advertising do not show the article sold. Instead, they create a certain feeling. Could this picture be used to sell railroad tickets, clothing, or men's cosmetics?

feeling that we should do something. We do not act because we think out a logical reason for doing whatever we do. Even if we offer a logical explanation for our actions, it probably is not the true reason. Those who sell goods know better than we do how our four natural desires cause us to do certain things, and they appeal to one of these desires when offering goods for sale. A strong feeling, which causes us to act, is called an emotion.

Is the desire to be masculine used to sell goods? To appeal to our desires to be masculine many clever ideas are developed. Do you feel that it is more manly to smoke a pipe than to smoke a cigarette? If you do, it is because the idea has been presented to you in an impressive way through advertising. Have you noticed that women's clothing often imitates men's clothing? The desire of girls to wear slacks and big sweaters is not based so much upon a need for comfort or convenience as it is upon the feeling of being strong like boys that it gives to girls. Small boys are much impressed by an opportunity to wear clothing like their fathers wear, but have no desire to wear clothing like their mothers wear. Can you name other styles that are based upon an appeal to make people feel strong and masculine?

Do some things help us to feel adequate? Every one of us secretly feels that he has many weaknesses which he does not want his friends to notice. Perhaps we may not like our personal appearance, the kind of automobile we ride in, our school marks, or our lack of social poise. We constantly use many devices to take our own attention, and the attention of others, from our real or imagined deficiencies. We try to emphasize some other quality to make up for what we feel we lack.

A boy or girl who is not doing good schoolwork is much more likely to start a fad than is a good student. If the poor student is able to attract attention to his clothes, others are less likely to think about his inability to do his work. When a fad is started by one pupil, other boys and girls may imitate it, and some completely impractical kind of clothing becomes popular for a short time.

By appeals to their desires to feel adequate, people are often persuaded to buy new models of articles when the old ones are giving satisfactory performances. An old radio may bring in programs satisfactorily, but if a neighbor buys one with new tuning devices and a showy cabinet, the owner of the old set may feel inferior because he does not own a new radio. He then buys a new radio, not because he needs it, but because he wants to feel as important as his neighbor. As a practical matter, it might have been more satisfactory to have new tubes and condensers put into the old radio than to buy a new one equipped with untested devices. Some experts claim that there was not a single important improvement in ordinary long-wave radios between 1930 and 1946. Yet many good sets were discarded during this time to buy improved models.

A common way in which people increase their feeling of being adequate is by paying high prices for ordinary articles. Thus it might be possible to buy a man's suit for about $40 that is as good in all important ways as is a $75 suit. Yet many men who have money will not buy a suit for $40 even though no one can see any superiority in their more expensive clothes. Expensive automobiles are similarly sold because the higher price appeals to the buyer's feeling of importance.

A common type of radio advertising is designed to make the listener feel inferior. In dismal tones you are told that you have bad breath, or that your body gives off unpleasant odors. Or you may be lead to believe that your teeth are dull and dirty in appearance, or that your skin is rough and ugly. The advertising is deliberately made unpleasant. The name of some product is repeated several times during the commercial announcement. You are likely to believe that the only way to avoid the bad results is to buy the product advertised.

Alcholic liquors are generally sold by appealing to people's de-

sire to feel adequate. Scenes in advertising pictures always show such liquors being used in the most luxurious surroundings. You will never see a photograph in a liquor advertisement of an intoxicated tramp sitting on the curb of a dirty street, because people know that tramps are not adequate to meet the standards of society.

How is the desire for romance used in selling? People who have goods to sell appeal to our desire for romance more often than to any other desire. After listening to a number of radio programs, you know that a large percentage of the time is given over to stories that are just as impossible as the Cinderella-and-the-prince story. These grown-up fairy tales are planned especially for women who must stay at home to do ordinary work while wishing for more romantic things to do. The women buy the advertised goods because the pleasant feeling produced by the play carries over to the article advertised, whether it be a soap, a linoleum, or an artificial cooking fat.

Cigarette advertising is commonly based upon the romance idea. You are familiar with the parked-car-and-moonlight pictures, and the expensive boats and beautiful girls that are used in cigarette advertisements. No attention to the truth is given in such advertisements. Nothing is said about the effects of tobacco upon the health, or the fact that it makes the breath offensive and not in keeping with the romantic scene. Such pictures cause an emotional feeling that somehow cigarettes are necessary for romance—and that is what the advertiser wants you to believe.

Borg-Warner Corporation

When you see a scene like this in a motion picture, do you think of the complex scientific machines needed to produce the picture and the sound? Or does the picture illustrate a daydream?

Girls are asked to believe that ordinary soap will make them beautiful instead of merely clean. In spite of the fact that cold creams are made of such common materials as mineral oil, sheep's-wool fat, cocoa fat, wax, and perfume, women are asked to believe that use of the cream can make them able to be charming to men. Such a belief will make a woman pay a dollar for a dime's worth of oils.

Perhaps you can explain now why the picture of a beautiful girl is the most common advertising illustration, whether the

product offered for sale is bottled water, tires, linoleum, toasters, snowshoes, or headache tablets.

How do advertisers appeal to the urge to live? Most people are afraid of illness and death. Because of this fear any device that can be offered to insure health or survival has a strong appeal to people. To this desire to remain alive are directed advertisements of patent medicines, safety glass, nonskid tires, life insurance, health foods, systems of exercise, and travel for improved health.

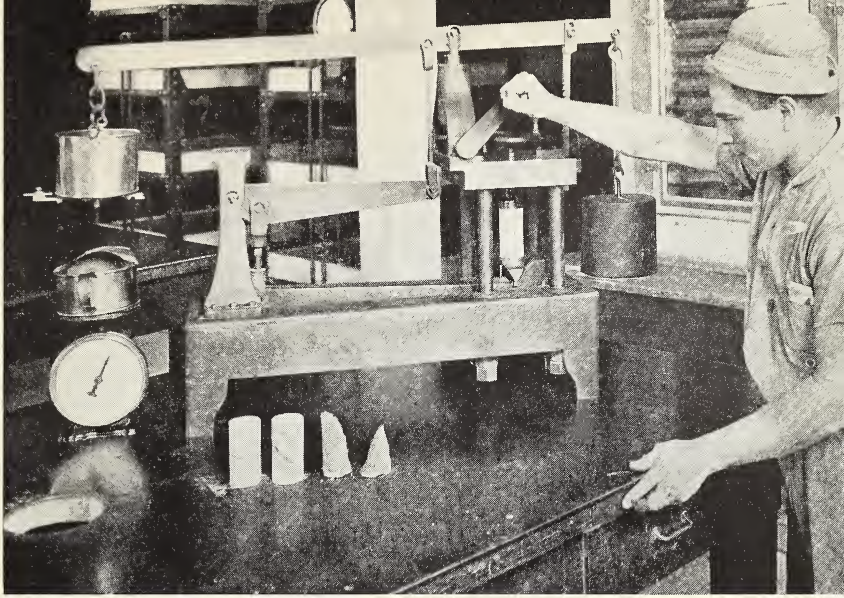
Some of the things listed are clearly desirable safeguards against ordinary and unavoidable risks. Others, particularly patent medicines and health foods, are usually outright frauds. Many patent medicines are definitely harmful. Because of false and misleading advertising, many people regularly take laxative medicines which seriously interfere with ordinary comfort and functioning of the body.

Should we be guided by our natural urges? If we follow our natural urges within reason, they will guide us in buying things that offer us genuine satisfaction. It is only when natural urges to action are not used with intelligence that people have difficulties. If the desire to be romantic and healthy causes you to use soap and water to keep clean, acting on the urge is desirable. If these urges cause you to spend your money on expensive cosmetics or faddy clothes or to buy some fake health compound, following them is bad. We must learn to direct our desires instead of letting them direct us.

Things to think about

Copy the following sentences in your notebook. Select the correct ending for each sentence.

1. A strong feeling which is likely to lead to action is (*a*) thinking (*b*) drinking (*c*) an emotion (*d*) intelligence.
2. Men pay $100 for a ready-made suit because it makes them feel more (*a*) masculine (*b*) adequate (*c*) romantic (*d*) alive.
3. Most lipstick advertising is directed at the desire to feel more (*a*) masculine (*b*) adequate (*c*) romantic (*d*) alive.
4. Advertising warning us that we have bad odors is directed at the desire to feel more (*a*) masculine (*b*) adequate (*c*) romantic (*d*) alive.
5. Women wear trousers because of their desire to feel more (*a*) masculine (*b*) adequate (*c*) romantic (*d*) alive.
6. Patent medicines are (*a*) good for us (*b*) frauds (*c*) poisons.
7. A psychologist studies (*a*) people's behavior (*b*) selling (*c*) buying.



Universal Atlas Cement Company

To improve the materials used in industry and building, millions of dollars are spent every year. The careful manufacturer tests all his products to know that they are of the desired quality. This machine tests the resistance of cement to crushing.

2. What goods do we buy?

Although we are influenced in our buying by strong natural urges, there are many other factors which enter into determining our final choice when we buy. We want articles which are durable [lasting], up to date, attractive in appearance, and which fit our own particular ideas and needs.

Are good goods constantly improved? Most manufacturers make a genuine effort to improve the products they make. It is not uncommon for a large concern to employ many scientists who constantly experiment to improve the materials and processes used in manufacturing goods.

To understand better how research is used to produce new and better goods, let us consider the plastic industry. A plastic is a material which can be molded into shape when heated or softened and which then hardens into a solid. The raw materials used in producing plastics may be oat hulls, formaldehyde, cotton, milk curd, coal-tar products, coal dust, or wood fibers. The plastics formed may be bakelite, rayon, cellophane, nylon, or other familiar substances with

Should a lamp be designed chiefly for the purpose of giving off light efficiently, or should it be chiefly ornamental? Which value does this lamp serve?

unfamiliar names. Plastics are used to manufacture toothbrush handles, cloth, buttons, compacts, jewelry, toilet articles, lenses for glasses and cameras, bottle caps, light-switch buttons, etc.

New products produced by research are often so superior to old ones or fill some need for which there was nothing available, that we immediately know that they will satisfy our wants. We may say that invention and research are the two great forces which have made our high standard of health and living possible. We can obtain the benefits of improved goods only by keeping up to date in our buying habits. On the other hand, we must not accept every claim that a new article is superior until we know that it is really the result of research and not merely the product of a salesman's imagination.

How are goods made attractive to our eyes? There are many things which we buy which have become standard—that is, they are quite satisfactory, and little further improvement is expected. One of the common ways of persuading people to buy new articles is to change their design to make them more attractive in appearance, even though no important change is made in the way they serve us. Kitchen sinks and gas ranges are not much more efficient than they were 10 years ago, but you can recognize the newer models by their appearance.

Many attempts to improve the appearance of articles may interfere with their best functioning. Lamp shades are often so built for decorative effect that they do not serve their important function of spreading light around the room. Use of aluminum paint on radiators reduces their efficiency in giving off heat into the room. Polishing table tops may cause them to produce glare harmful to the eyes. Much furniture is designed with more attention to appearance than to durability or comfort.

Expensive and useless gadgets have been added to automobiles, while basic factors of safety have been ignored. For example, bright metal finish in front of the driver increases glare. Metal in front of the driver and front-seat

passenger should be replaced with rubber crash pads to prevent injury when collisions occur.

It is likely that most attempts at decorating articles have no important effect upon their usefulness but do increase the buyer's satisfaction. For example, perfume is not changed by the kind of bottle in which it is sold, but a fancy cut-glass bottle is more pleasing to look at than an ordinary round one, and will help the manufacturer sell more perfume.

It is said that about 85 per cent of all our impressions come to us through our eyes. If this is true, we are more likely to buy those things which are attractive in appearance.

How do salesmen get our attention? Even though we may have decided to buy an article, it is necessary for it to be called to our attention in some way to make the purchase possible. When we are hungry we need no persuasion to eat, but the sight of a neon sign makes it easier to find a restaurant, even though the sign adds nothing to the quality of the food. There are many ways of getting attention. A flashing light attracts the eye more strongly than does a steady light. A large or a bright sign attracts attention better than a small or a badly lighted sign. The more expensive gasoline is sold in some stations from the pump painted red. We are all familiar with these means of getting attention in a favorable way.

Some other methods are not so familiar to us. Use of perfume is one such method. For an experiment a scientist bought four identical pairs of stockings. One he perfumed with sachet, one with a fruity odor, one with narcissus, and one he left without perfume. The four pairs of stockings were then put into boxes. Many women were asked to judge the stockings and select the pair having the best quality. Exactly half the women selected those with the narcissus scent as having the best quality, almost a fourth selected those with the fruity odor, and about a fifth of the group selected the sachet-perfumed stockings. Only 8 per cent of the women selected the unperfumed stockings as being the best. This experiment shows that attention may be obtained in ways of which we are not aware, for none of the women knew that the stockings were different only in the scent. In fact, most of them probably did not notice the scent consciously at all.

A great many common materials—paints, soaps, foods, tobac-

Why do many girls prefer to wear scarves instead of hats?

cos, leather, and plastic goods—are regularly perfumed to increase their appeal.

Before we buy, it is necessary to have the article offered for sale called to our attention in a favorable manner.

Why do styles change? The word *style* has two meanings. One meaning applies to the fundamental design of an article. The other meaning applies to unimportant, deliberate differences between similar articles to make them sell. This latter meaning of style is sometimes called fashion.

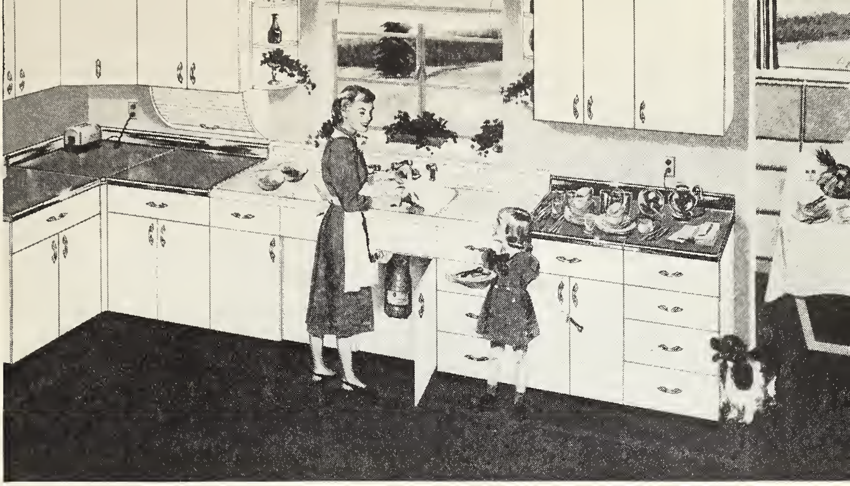
There are some articles sold largely on the basis of the appeal to fashion. Women's hats and dresses, and to a considerable extent shoes, coats, and stockings, are sold through an appeal based on style. The object of style changes is to cause people to discard articles more quickly than they would otherwise. Style changes are not likely to encourage wise buying for quality or durability, because a durable article outlasts the style. Style-conscious women spend more money on clothing than do men and, in general, obtain less for their money.

The appeal of changing styles is not limited to clothing, however. Many of the changes that are made in automobiles are not based upon any important improvements, but are made only to make the owner dissatisfied with the appearance of an old-model car. On the other hand, important improvements are frequently delayed by people wanting a style that is unsound. For example, a completely streamlined automobile is shaped more or less like an egg, and is more efficient than the older type cars. Yet the change to a streamlined automobile is held back because people have been educated to a different style.

Some style changes make a device less useful. In recent years there has been a fad of buying small watches and small cameras. A small watch generally does not keep time as accurately as a large one of the same quality and it is more difficult to read accurately. A small camera generally does not take as satisfactory pictures as a large one.

Some style changes are desirable, for design as well as quality should gradually improve. Style changes that are too extreme, or which occur in rapid succession, are definitely bad, for they cause people to discard useful articles. The wise buyer will resist buying any article in extreme style to protect his investment in what he already owns.

Occasionally fashion leads to definitely harmful effects when applied to food or clothing. For example, there really is only one correct design for shoes—the low-heeled, broad-toed shoe which fits firmly around the foot. The only changes from this style which are harmless are those which change the combinations of leather and decorations put on the shoe. Any change of the shape of the shoe, the height of



Youngstown Kitchen, Mullins Manufacturing Corporation

Effective planning, designing, and manufacturing methods make possible this efficient and attractive kitchen at prices many people can afford.

the heel, or the support given the foot will result in harm to the wearer. Eating bran as a breakfast food was once considered good style, and as a result many people were made uncomfortable or actually ill by the harsh material in their intestines.

Do lowered prices help sell goods? People who do not desire to pay high prices to make themselves feel more adequate prefer articles at lower costs. Because of more efficient methods of manufacture, the prices of many articles have been reduced, and as a result more articles are sold. The price of a good automobile dropped from $2500 to about $800 to $1000 within the 40 years between 1900 and 1940. Refrigerators which sell today for $250 are better in quality than were those which once sold for $500.

There is no better way to make an article attractive than to improve it and at the same time sell it for less money.

Do salesmen consider peoples preferences? It is easier to sell an article that the buyer is ready to accept. To learn what buyers prefer, careful count is made of what sells best. In so simple a matter as choosing pencils, it is known how many people prefer yellow, red, green, and blue. Another way of learning preferences is to ask people what they like, either by telephone or by sending them lists of questions to check. Coupons attached to advertisements are used to learn what advertisements are most appealing to people.

DEMONSTRATION: ARE STYLISH SHOES WELL BUILT?

What to use: Discarded shoe of extreme style, standard shoe, knife, hammer.

What to do: Cut the shoes apart, cutting through the heel, the counter, the toe cap, if any, and through the sole. Examine them carefully for presence of paper, cloth, and wood. Do the shoes have wide enough welts (strips on the edge of the sole) to hold the sewing?

What was observed: Do the shoes seem to be made well or poorly? Which is the better shoe?

What was learned: What do you know about shoe construction as a result of your observations?

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

Materials which can be molded when softened by heat or moisture, and which harden, are called —1—. Experiments and investigation on a a large scale are called —2—. The eye is attracted best by a light which is —3—. Changes in —4— are used to make people discard old but satisfactory articles. About —5— per cent of all impressions come first through the eye. Every time you mail in a —6— you are telling the advertiser that you have read his advertisement. A properly constructed shoe has a —7— heel. Prices for most articles are gradually becoming —8—. People can be caused to give favorable attention to stockings by use of —9—.

3. Does advertising sell goods?

Whether we know it or not, our habits of buying and our habits of living are influenced by advertising. Many words which we think of as being the common names of articles are in reality copyrighted [kŏp′ĭ·rīt′, the sole right to use in selling] trade names made familiar to us by advertising. Can you think of such names applied to cameras, vacuum bottles, transparent wrapping paper, or other articles?

Advertising is defined as offering for sale. Actually it is much more than that. It is a big business engaged in the work of influencing people to do what they would not do of their own accord. The work of advertising is to attract our attention, arouse our interest, and offer a brief message which will cause us to buy.

Advertising is seen everywhere we go. Airplanes tow signs above the crowds at games and races. Skywriters trace out messages above cities. Billboards block our view along the highways. Loudspeakers on trucks and in doorways shout messages into our ears. In moving-picture theaters and on the radio and television we have advertising mixed into our entertainment. Printed advertising is everywhere—in newspapers and magazines and on handbills, calendars, and posters.

Why do people advertise? There has always been some advertising since man first began to buy and sell. But it is only within

recent years that advertising became essential to maintaining our ways of living. Our methods of producing goods today are different from those of 60 years ago. Today we have mass production. Automatic machines produce thousands of articles exactly alike, efficiently, and at low cost. In order to keep the machines running all the time, it is necessary to sell huge quantities of all kinds of goods. Unless machines are kept busy, the cost of goods rises. Only by advertising can the goods be sold.

There is only one reason for advertising. That is to sell goods or services at a profit to the one selling.

Does advertising appeal to the emotions? Although every successful advertisement carries an emotional appeal some kinds of advertising are based more on emotions than are others. While it is good and proper to give gifts to your parents, there is no need of having a special day for this purpose. Mother's Day and Father's Day are now commercialized devices to sell gift articles. Fruit in gift packages is sold for many times its true value. Perfume and cosmetics are similarly increased in price to many times their true value when sold in gift packages. Christmas and Easter are commercialized so that they do not now generally have their original meaning. Sentimental and sad occasions are used for high pressure selling, so that funerals, weddings, and birthdays often cost average families much more than they can afford.

Is some advertising educational? When a new product is introduced, it is necessary to acquaint people with it and to persuade them to try it. It is estimated that the time passing between first offering a device for sale and its coming into common use is 20 to 30 years. Before people are educated to use any article, much money must be spent in advertising. The more effective the advertising, the shorter the time until the article is commonly sold and the price is reduced.

Many things are becoming more common today. Some of them are readymade houses, air conditioning, radiant heating, plastics, improved lighting, artificial cloth fibers, streamlined automobiles, television, privately operated airplanes, and noiseless transportation. Whether or not these devices are in common use 30 years from now depends almost as much upon success in advertising them as upon the work of engineers in improving them.

Educational advertising has raised the standard of living of all our people. Today people live in better houses, have better furniture, drive more and better automobiles, and are cleaner and healthier than they could have been without advertising.

What is good advertising? Good advertising above all else tells the truth in an interesting and attractive way. It gives not only true information about the

article for sale, but explains what the information means. For example, a good advertisement offering a man's suit for sale might state, "The cloth is virgin wool worsted [wo͝os′tĕd]. Rayon stripe. Weight, 15 oz. per yard. Breaking strength: warp, 105 lbs.; filler, 80 lbs. Guaranteed colorfast." A person selling cloth of this quality has nothing to lose by telling about it. Only the maker of inferior quality materials is afraid of the truth.

Unfortunately some advertising is not very good. Even educational advertising which eventually does much good is likely to contain statements that do not tell the actual truth.

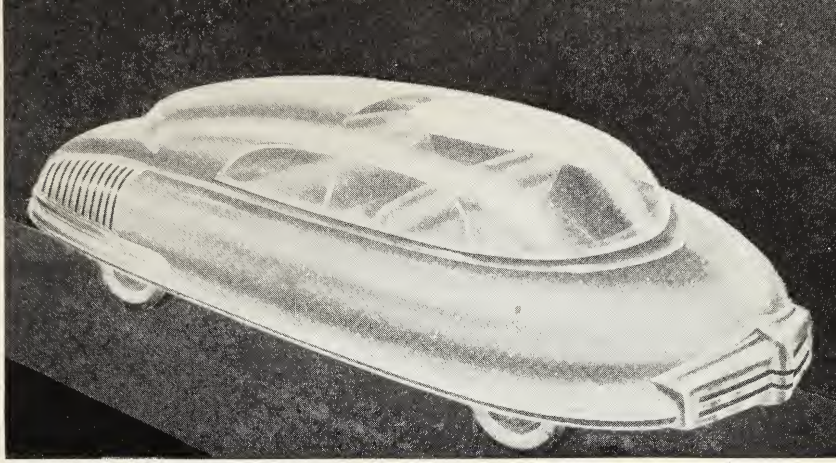
How does advertising suggest meaning? Probably three-fourths of the advertisements you may find do not offer any information at all. Instead you will find phrases like these: "Nu-shoes put new pep into you." "Never before a farm radio like our new model." "Colorful smartness combined with cozy warmth." "The skin that men admire." These phrases are meaningless. You know that shoes, particularly the high-heeled shoes illustrated in the ad, cannot put pep into you. You know that the new model radio will be replaced within a few months by another new model that is different only in unimportant respects. A blanket described as having cozy warmth may be made of fuzzy cotton. And no soap can produce a skin that men admire. In spite of their lack of meaning, such slogans are effective in selling goods.

Most people do not know how to get the real meaning from what they read. Instead, they are willing to put their own meaning into a slogan that suggests something. Just how warm is "cozy warmth"? How many degrees on a thermometer does it equal? How bright is "colorful smartness"? What does "Hits the spot" tell you?

A common type of advertising appeal is through the use of words having pleasant or approved use. Such pleasant sounding words as premium, gold bond, champion, action, king size, fresh, glamor, scientifically tested, vacation, miracle, and magic are applied to goods in completely meaningless ways. Especially on the radio, frequent repetition of some phrase, slogan or series of letters is a means of catching attention.

Many advertisers do not even use words to suggest ideas. Instead they use pictures. A scene in the woods suggests adventure and appeals to the desire for manliness. Boys are easily influenced by such a picture to want boots, a knife, or a candy bar. A picture showing a couple in a canoe outlined against a full moon will sell more cleansing cream than will a full page of accurate information. As long as people are willing to be influenced by such meaningless suggestions, advertisers will continue to use them.

To sell cigarettes the radio an-



Great Lakes Steel Corporation

What are some advantages of a rear-engine, streamlined automobile? Why have automobiles been manufactured on another pattern for so long a time?

nouncer praises them for being mellow; made of toasted, long-burning tobacco; and easy on your throat. Soft music and the speaker's voice suggest more than outright statements would. If an advertiser told you directly that cigarettes are good for you, you would not believe him. Consequently, he only suggests the idea.

Is some advertising dishonest? Some people think that any advertising is dishonest which causes you to form wrong impressions. Others think that advertising is not dishonest unless it contains false and harmful statements. Some advertising is certainly dishonest in its effect, regardless of how carefully its slogans may be worded to avoid falsehood.

Advertising of alcohol and tobacco carefully conceal the fact that both products are definitely harmful to the one who may use them. To suggest to a person that using such things is approved by doctors, teachers, or successful businessmen is dishonest.

Some advertisements are clearly dishonest. In cheap magazines, printed on rough paper, you can find advertisements of false eardrums, magic X-ray tubes, electric belts, and cheap telescopes. Some of these advertisers do not even mail anything in return for your money if you do answer their advertisements. If they do, the goods you receive are worthless.

A common form of dishonesty is the use of endorsements. An endorsement is a recommendation of an article. While a few famous people may actually use the articles they endorse, most of them do not. Even if they did, their opinions are worthless. Of what scientific value is the opinion of a baseball player concerning the effect of cigarettes upon

the nervous system? It is well to remember that no famous scientist or doctor endorses anything. Such men value their honor far more than they do the money their endorsements would bring.

What is nuisance advertising? There are some forms of advertising that may not be dishonest but are annoying. Such advertisements include handbills thrown into entryways of buildings, posters on buildings, billboards along country roads, and other devices which are unsightly. Billboards make the roadside unattractive and may attract a driver's attention from safe driving. Many progressive communities have forbidden their use. In regions where tourist trade is important, it is foolish to spoil scenery with billboards.

Any advertising directed at small children is nuisance advertising. A child does not know whether certain breakfast foods or other products are good for him. Yet the child can annoy his parents to obtain the cheap toys offered by such advertisers until they may buy against their better judgment.

Advertising offered in the form of a comic strip is misleading. By making the characters speak, greatly exaggerated statements can be made which no one would believe if they were offered directly.

DEMONSTRATION:

ARE HOUSEHOLD CLEANSING POWDERS GRITTY?

What to use: Any common household cleansing powders, two pieces of glass.

What to do: Polish the glass with a soft cloth. Use pieces of glass free from scratches. Between the glass plates put a pinch of the cleanser and moisten it slightly. Rub the plates together for some time. Listen as you rub them, to find if there is scratching. After a considerable length of time, examine the plates in strong light to see if they are scratched.

What was observed: What do you observe? Is a cleanser which scratches safe to use on silver and fine dishes?

What was learned: Is cleanser effective because it cleans, or because it removes part of the surface?

Things to think about

Copy the following sentences in your notebook. Select the correct ending for each sentence.

1. A phrase like "The Scratchless Cleanser" is a (*a*) simple statement of fact (*b*) meaningless slogan (*c*) deliberate falsehood (*d*) trade-mark.
2. Advertisers give away small articles free (*a*) because they can afford it (*b*) to see how many people read their advertising (*c*) because they must bribe people to buy their product.
3. The truth of advertising is (*a*) guaranteed by law (*b*) guaranteed by all magazines (*c*) open to question.
4. The greatest and most genuine public good done by advertising is to (*a*) sell products for a profit (*b*) provide free radio entertain-

Swift and Company

The whole family should plan together when spending family income. Is spending money to improve your house or your farm a good investment?

ment (*c*) raise the standard of living.

5. Most advertising is designed to (*a*) educate the public (*b*) sell the product (*c*) make magazines attractive.
6. The best advertising (*a*) tells the whole truth (*b*) suggests true ideas (*c*) uses slogans.
7. The advertising message is commonly (*a*) offered only once (*b*) repeated many times (*c*) changed daily.
8. Advertisements should not be directed at children because (*a*) they have no money (*b*) it is unfair to take advantage of a child (*c*) children do not read them.
9. Advertising is essential to sell the products of (*a*) radio makers (*b*) comic-strip artists (*c*) mass production.

4. Why should we buy carefully?

In a modern world nobody can buy or use all the things offered for sale. Factors which determine what you can and should buy are the amount of money you have to spend, your needs for food, clothing, safety, and shelter, your personal interests, and the demands of the social group in which you live. But these factors are general. They do not help you to know what particular articles to buy or to refuse to buy.

Why is a budget needed? A budget is a detailed plan which shows how much money is available for a given purpose, and how it is to be spent. A budget is essential to wise buying. Many families have informal budgets based upon knowledge of how much has been spent in the past. It is better, however, to prepare

a formal budget in a special book. In this budget absolute needs must come first. Money for rent or taxes, food, home operation, health, transportation, and clothing must be provided. Because incomes and costs of living vary greatly in different regions, and because size of families and of family income also vary greatly, it is difficult to set up any kind of budget which will be of value to every family.

Budget buying does not necessarily mean hunting for low-cost or cheap articles. Some stores advertise as "Budget specials" their lowest cost merchandise. *Budget* does not mean *cheap*. Many stores try to discourage planned buying in this way.

The chief value of a budget is to determine, after needs are met, how much money is needed for different things and to make possible wise choice of things to buy. For example, over a period of about twenty years, including both high cost and low cost periods, the average daily operating expense of an automobile has been between one and two dollars per day. Many families cannot really afford to spend two dollars a day on an automobile, but do not know how much they are actually spending on it. If a choice is finally made to operate an automobile and to spend less on rent or house cost, clothing, amusements, and other items, the choice is at least made intentionally.

What are some tests of intelligent buying? There is no one set of rules which will guarantee intelligent buying, but these questions will be of value in planning purchases:

1. Is the intended purchase made as a result of careful planning instead of as a result of a sudden impulse?
2. Has sufficient time been spent on buying to assure the purchaser that he will not find another article with more value or appeal?
3. Is the article purchased the one of lowest price for the necessary quality?
4. Is the article satisfactory from the standpoint of health and safety?
5. Will the article give fully satisfactory service?

Is price a guide to quality? People generally believe that by paying more one can obtain goods of better quality. This belief is false. While it is true that some articles are priced too low to make good quality possible, the relation of price to quality is generally low. For example, in one series of tests, the best razor blades were sold for about three cents each, while widely advertised blades selling for ten cents each were found to be of unsatisfactory quality. In one test of vacuum cleaners it was found that one cleaner selling for $21.95 was superior in quality to another selling for $89.50. One good quality toilet soap sold for 26 cents per pound of dry soap, while another soap of poor quality sold for $1.99 per pound.

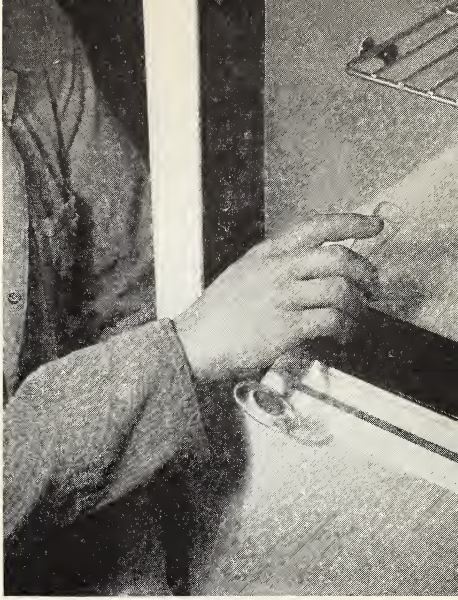
The sensible conclusion is that price is not a test of quality but that other factors must be considered.

Does the article protect health and safety? Careful examination or tests of many articles and materials show that they are in some way dangerous to health or safety. Some soft drinks and some acid fruit juices may dissolve enamel of the teeth. Many common foods may contain chemicals which are dangerous to the health of some people. Fuzzy fabrics have been a frequent cause of death from flash burning. There have been many cases in which sweaters and children's cowboy suits made of such material have been set afire accidently.

Such devices as can openers and egg beaters with exposed gears may pinch and tear the flesh. Some can openers drop bits of metal into the food. The common roller-type washing machine wringer injures many people every year. Many types of electrical equipment permit enough current to escape to cause serious injury. Few people buy shoes that really fit.

Many kinds of poisons are found in various materials. Chemicals used in hair dyes, deodorants, food preservatives, sprays, gasoline, nose drops, and other common materials are poisonous to some degree.

These examples merely serve to indicate that special information about every article or material purchased is highly desirable.



Which means more to you, the phrase "enduring whiteness" or "the result of a laboratory test"? The man is pouring acid on the enamel of this refrigerator to learn if it will really last.

Does advertising improve quality? One purpose of advertising campaigns is to lead you to believe that only advertised goods are of good quality. As a matter of fact, a few widely advertised goods are actually better than most unadvertised goods, because the manufacturers try to maintain a high standard quality. But in general such cases are rare. The superior qualities of nationally advertised goods usually exist only in the mind of the man who writes the advertising copy. The relationship between the amount of advertising and the quality of goods is very slight.

Is upkeep part of the cost of buying? The life of an article

of good quality bought at a reasonable price can often be prolonged by cleaning, repairing, or other kinds of special care. Articles which cannot be kept up to a good standard of performance and appearance must be considered poor buys. When you buy shoes, select those which can be shined easily with cheap materials. They are better buys than those which cannot be cleaned or which require expensive materials and labor for cleaning. Keeping shoes shined makes them wear longer.

The cheapest and most satisfactory method of cleaning most things is by use of soap and water. Rugs are cleaned in laundries by washing them. Walls which are properly finished may be washed. The cost of cleaning wallpaper and calcimine [kăl′sĭ·mīn, a material used in decorating plastered walls] must be added to the original cost in comparing them to washable materials. You know that the cost of laundering clothes is much lower than the cost of dry cleaning them. Every garment should be purchased with full knowledge of the cost of keeping it clean. Another advantage of laundering is that it can be done safely at home. There is no method of dry cleaning which is safe for home use. By washing them, you can add to the useful life of powder puffs, wool shoe-polishing brushes, lamp shades, shoes, basketballs, neckties, and furniture covers.

Some newer upholstery fabrics and wall coverings are plastic-coated and may be cleaned with soap and water.

Paint and varnish help to preserve wooden surfaces and improve the appearance of many household articles. Before buying an article, one should examine it to see if its finish can be maintained over a long period of time.

Proper use of white paint reduces light bills and cuts down danger of accidents caused by poor lighting. Ceilings, stairways, halls, and the insides of drawers and closets in particular should be painted white.

Prompt attention to repairing small damage is necessary for keeping stockings, clothing, furniture, and tools and other equipment in economical use.

DEMONSTRATION:

HOW MANY THREADS PER INCH ARE IN COTTON CLOTH?

What to use: Magnifying glass, cotton samples, ruler.

What to do: Mark off a one-inch square on the sample, and count the threads each way. Check your count in another place. Take out some threads, and see if the threads of the different samples seem to be of the same weight. Let each pupil count a sample different from that counted by other pupils.

What was observed: Make a record of your observation.

What was learned: Do you think that the number of threads in cloth determines its value?

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

A —1— is an estimate of income and expenditure of money. The average cost of operating an automobile is —2— per day. Purchases should be made as a result of —3— instead of impulse. The relation between price and quality is —4—. The —5— of the teeth may be dissolved in acids. The relation between price and amount of advertising is —6—. The best way of cleaning most articles should be by the use of —7—.

5. What new materials are being developed?

Our great-grandparents did not have to make much effort to keep up-to-date on new developments in modern materials. The kerosene lamp, the railroad, and a few improvements in making cloth were in process of development. But in general there were few new articles to buy, and people depended for most things upon local industry. Today even an expert cannot keep fully informed on all developments in even one field.

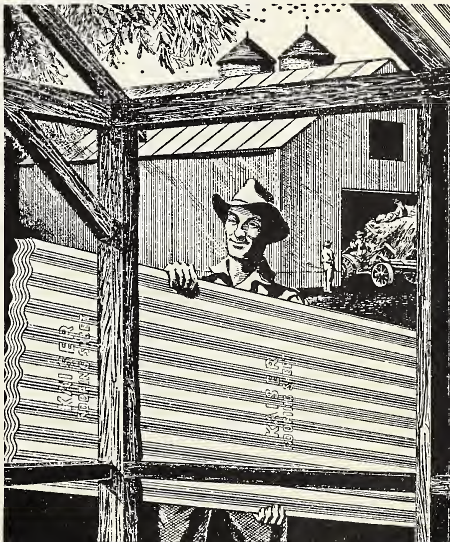
Is glass being improved? You may have a glass springboard at your pool, or glass backboards for your basketball gymnasium. Even more practical uses of toughened glass include its use for automobile windshields and windows, watch crystals, and goggles. Glass is hardened by an annealing process. It consists of careful heating of a special glass to the desired temperature and its slow cooling under controlled conditions.

If your great-grandmother had put a glass dish into a flame she would have expected it to break, and it would have. But you may fry eggs in a glass pan over a gas flame hotter than any your great-grandmother ever used for cooking. You do not have to open the oven door on some stoves to check on the baking of your cake. Instead of cooling the oven by opening the door, you can look through a glass door.

You can buy glass that will let

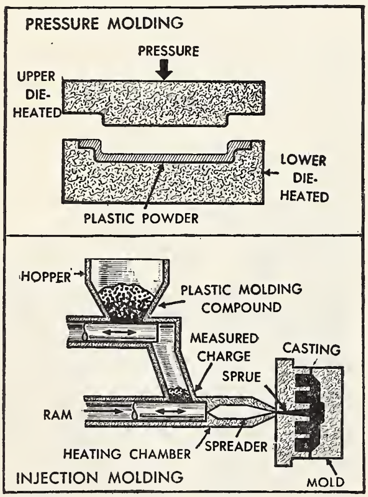
One of the important recent uses of aluminum, a light metal, is for walls and roofs of farm and industrial buildings. It is easy to handle and highly resistant to weather.

Permanente Products Company



in or shut out almost any kind of ray you want to control. Some glass shuts out heat rays and lets through light, while other glass lets through only the heat rays and stops the passage of light. One kind is used in windows, the other in heat lamps.

Are light metals useful? For a long time no other metal was so useful as iron. But iron is heavy, and unless it is specially mixed with other metals, it rusts. The first useful light metal developed, aluminum, was soft, porous, and relatively weak. While steels have been greatly improved, aluminum has been improved even more. One alloy [mixture] of aluminum and small amounts of several other metals has developed strength equal to that of mild steel of the same size. The great advantage of aluminum is that it weighs only about one-third as much as iron. Thus it is particularly useful for making airplanes, railroad cars, and furniture.



Society of the Plastics Industry

These diagrams show two common methods of forming articles made of plastics. Can you explain how the machines work?

It is also possible to put coatings harder than glass on aluminum. These coatings are formed by action of electricity during the finishing process. They can be given almost any desired amount of shine, or can be finished with long-lasting colored surfaces. A roof of such material would last much longer than most houses made of wood. Aluminum is also used for traveling cases, wrapping foils, and containers.

A metal that weighs about two-thirds as much as aluminum is magnesium. In its pure state it is not very useful for making things. But alloys are now made which are strong. It has been used commercially in wheelbarrows, piano frames, bicycles, and cooking utensils.

Can you imagine a large comfortable davenport made of magnesium, sponge rubber, and plastic cloth which can be carried by one woman of ordinary strength, and washed with water and soap or one of the new cleansers?

Are plastics in common use? Plastics have become so common that most of us are not really aware of their many uses. Window and shower curtains, raincoats, radio cases, buttons, lamp reflectors, clock cases, electric

switches, dominoes, handbags, steering wheels, dishes, rowboats, camera cases, dentures, lenses, toothbrushes, eyeglass frames, telephone bases and receivers, tennis racket strings, electrical insulation, phonograph records, shoe soles, and garden hoses are commonly made of plastic materials, to name a few.

There are so many kinds of plastics, and so many ways of using them, that manufacturers have not yet discovered the limits to their possible use. Sometimes unsatisfactory results have been obtained because of faulty choice of one kind of plastic instead of another, or because the manufacturing process was not properly controlled. Some plastics do not set with full strength unless manufacturing and temperature conditions are controlled quite exactly. Many articles of amazing excellence have been made from plastics. Also some plastic articles have been put on the market which are so poor that they could not be used more than a few times, or perhaps not at all. Dishes have been made that cracked in hot water; buttons have been made that soaked off in the washing machine; and rain capes have been made which cracked when folded. Today there is great improvement in most articles made of plastics, but having a thing made of plastic does not guarantee that it is durable.

Are more surprises coming? If you are accustomed to having a bulky radiator in your house, or to chopping wood for a heating stove, you may not believe this story. It is possible today to lay on your floor a kind of rubber mat that can be plugged into an electric circuit. This rubber mat will conduct enough current to heat your house. You have probably seen much rubber which will not conduct electricity. This new rubber is specially made. It will not become hot enough to melt or to set anything on fire, and the heat it gives off is so gentle that you are comfortable without knowing where the heat comes from. These rubber mats may also be put into walls or ceilings.

It is possible to cook by using radio waves. Ordinary things which are nonconductors of low voltage alternating electric currents become conductors when the current is increased to two or three million changes of direction per second. By arranging a special kind of radio tube, connected to two plates of metal, you can cook most kinds of solid foods. The food is placed between the metal plates. The food cooks on the inside just as fast as it does on the outside. A large roast may be cooked in a few minutes.

When should you buy new things? There are several things to remember about any new device offered for sale. The first is that articles are rarely perfected when first offered to the public. They must be given a tryout in use to find unforeseen difficulties and failures. The second is that

new articles are usually very high priced. The research behind a new product and the lack of mass production methods make the new article expensive. Even so, the manufacturer often loses money for some time on new articles.

A third difficulty in buying a new article is the difficulty of obtaining simple, honest information about it. You are not told simply that the product is new, that it will do certain things, and that certain scientific tests show its limits of use. Instead the advertising department makes claims that the new product will do things that nothing else can possibly do. You are so confused by unreasonable statements that you scarcely know what the advertiser is talking about. Part of this difficulty comes from the manufacturer trying to teach you his brand name.

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

Glass hardened or toughened by controlling heating and cooling has been —1—. An —2— is a mixture of metals. Aluminum weighs about —3— as much as iron, and magnesium weighs about —4— as much as aluminum. A group of materials which set and become solid under temperature changes are called —5—. —6— are commonly shaped by pressure or molding. Ordinary rubber is a —7— of electricity. A radio wave may produce —8— when passing through some materials. New materials are likely to be —9— in price.

6. Can buying be a science?

If you depend only upon your own judgment in buying, getting satisfactory products of any kind is a matter of luck. You ordinarily have so little dependable information about most things that you might almost as well buy blindfolded. Yet it is possible to get scientific information about buying, for methods of testing many kinds of goods have been developed. Perhaps the most reliable tests are made by the United States Bureau of Standards. This bureau tests materials brought by the United States for the armed services and other branches of the government. Its services are also available to manufacturers who are willing to pay a fee for the work.

Commercial organizations now offer to the consumer much the same service that the Bureau of Standards offers to the government. Consumers' Research, Inc. tests and issues private reports upon goods to their subscribers. It is believed that this service is the best available to the average consumer. There are also consumers' bulletins issued by the United States Department of Agriculture.

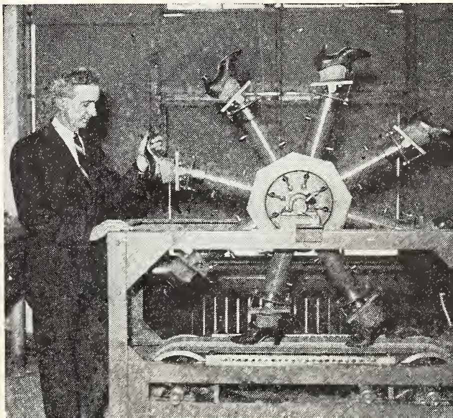
There is no way for the consumer to test such articles as washing machines. A fair test might be set up this way. All machines would be filled with water of the same temperature and hardness. Then standard white test clothes, soiled with different kinds of materials, would be put in each machine. The machine would be loaded to advertised capacity. The clothes would be washed for the same length of time and dried. The amount of light reflected from the originally white clothes would be measured by a photoelectric meter [a device which produces a current when light shines on it]. The actual whiteness of each tubful of clothes could thus be measured. In an actual series of tests, it was found that the most expensive, automatic tumbler-type machines do not wash clothes as clean as do the standard types of washing machines. Next the machines would be run till they wore out. It is interesting to note that one manufacturer of an automatic machine in his own tests obtained better results for his machines than for other makes. He used hotter water than is ordinarily used in home washing in his machine, and hotter water than he put into competing machines. To be of value tests must be fair and honest.

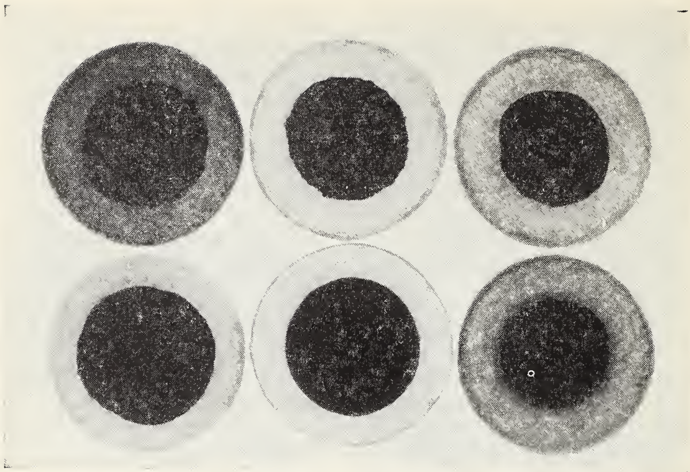
Tests for purity of foods are difficult to do. Only a skilled chemist can say exactly how much of a given chemical is found in a certain food. It requires skill to determine just how much trisodium phosphate [a chemical used as a water softener and in boilers] has been put into a certain kind of cheese to make it spread easily. It is difficult to detect spoiled materials in otherwise pure foods. Only experts can make such tests.

Another way of judging the quality of goods is by gaining a knowledge of materials and processes that are used in manufacturing them. As an example, we may consider furniture. Much of the furniture which looks like walnut is really made of some cheaper wood, stained and grained to imitate walnut. Or a cheaper wood may be covered with a thin layer of walnut which is held in place by glue. Such a covering of one wood with another is called veneering. To realize how extensively walnut is imitated, it is helpful to know that only one per cent of

The walking machine is used to test the durability of women's shoes. The belt provides a walking surface. Springs force the shoes against the belt to correspond with the weight of the walker.

National Bureau of Standards





The X ray is helpful in buying golf balls. The cores of some balls are irregular; some are off center. The average consumer has little chance of knowing what he is buying without help.

all walnut furniture sold is solid walnut. The other 99 per cent of the furniture is either veneered or imitation walnut. Much veneered furniture is as strong and durable as most people require and can afford.

Can you make tests at home? Most people will not go to the trouble of testing goods at home. Many advertisers know this and advise people to make tests which they know will not work out as described. Most scouring powder will scratch glass. Yet a manufacturer of scouring powder knows that it is safe to tell the buyer to rub the powder between pieces of glass to see if it will scratch because few people perform the experiment. If you are interested in making tests, there are books which describe simple experiments which can be done at home. For a pupil with some skill in science, these books provide fun and information.

Too often we test goods unwillingly, whether we wish to or not, by buying and using them. By the time we have tested the product, our money is gone. Even if the products we buy are good, we still have no guarantee that the next goods of the same kind we buy will be of the same quality.

Are advertiser's tests dependable? Many stores and some magazines claim that they test scientifically all goods which they sell or advertise. The dependability of such tests is always to be doubted. Testing is expensive and requires great skill. Moreover, if a firm selling a certain kind of goods finds that its product is unsatisfactory in some way,

it is doubtful that the company will take the chance of losing profits by telling the whole truth to the public.

Those who sell goods realize that many people want scientific-sounding information about the goods they buy. Many companies are willing to give such information about the goods they buy. Many companies are willing to give such information about their product to the public, even if they must make it up. Such so-called scientific testing may be considered another form of advertising.

How can you protect yourself from mistakes in buying? Some stores and firms have well-established reputations for fairness in returning money for unsatisfactory goods. The experienced buyer will learn which firms these are and will buy from them. If you are in doubt about the reputation of a firm, it is well to ask for a written guarantee signed by a responsible person. A guarantee should cover the more important possible flaws in the article bought. You should remember that the word "Guaranteed" when used in general advertising means very little. You cannot recover damages in a lawsuit on such a guarantee. On a label a quarantee against definite faults does have meaning.

You should learn to read labels. The "large economy size" sometimes is not that at all. On the shelves of a store were 16-ounce packages of a breakfast food for 21 cents, and 24-ounce packages for 39 cents. The food in the 24-ounce package cost about .3 cent per ounce more than that in the small package.

If it is possible, buy standard foods labeled with government grades on the container. Some canned food has its grade on the label. In buying cloth ask for thread count, breaking strength, and written guarantees against shrinkage.

The right to take back unsatisfactory goods does not mean that you should buy with the idea of trying out goods instead of buying carefully. Unnecessary returning of goods adds millions of dollars to the cost of selling every year, and you and other consumers pay the bill. Women are much worse offenders than men in changing their minds about goods bought. Careless buyers have forced some stores to refuse to accept returned goods. Other stores may accept returned materials, but keep a record of the customers who return more than the average, and refuse them credit. Too often stores do nothing except to add the cost of returned goods to the selling cost, and other customers must pay for the stupidity of the few poor buyers.

Why do we need legal protection? At present legal protection is given by the Federal Food, Drug, and Cosmetic Act passed in 1938. This Act applies to some foods, medicines, and cosmetics [skin preparations]. While it offers considerable protection to the consumer, its weakness is that it is difficult to enforce. Nor does the law cover all possible sources

of danger in food and drug poisoning.

There is no legal control of production or sale of fabrics except for wool. When we buy most cloth we do not know of what it is made, how much it will shrink, how well it will launder, how strong it is, or if it will fade. Yet the need for protection is considerable. Before the Federal Wool Products Labeling Act was passed, in a series of tests of many samples of "pure" wool, the samples were found to contain, on the average, 40 per cent cotton. Wool cloth now must be correctly labeled. Many new fabrics have been placed on the market without sufficient testing.

Most household equipment is not required to meet specific requirements. In some fields, such as the manufacture of electric refrigerators, there has been great progress and no legal check is necessary. In others, there is much need for improvement.

Local sale of food is controlled only by local laws. Your own state, county, or city health department provides your only protection when you buy meat, milk, eggs, and vegetables from your local producers. Restaurants, drugstore counters, and other places serving food and drinks often use unclean or filthy equipment in violation of the law. Dead insects, mold, rat hair, lipstick, and of course germs are too often found on food or dishes.

Laws cannot take the place of intelligent care in buying, but they can be used to protect us from those practices which are likely to cause us to be injured. Many people are not capable of learning how to buy wisely. Wherever irresponsible or uninformed producers offer for sale something that can injure the public, laws should be passed and enforced to control the production and sale of such articles.

DEMONSTRATION: DOES SOME TOOTH PASTE CONTAIN STARCH?

What to use: Tooth-paste samples, iodine.

What to do: Spread the sample of your favorite brand of tooth paste on a piece of white paper, and put a drop of iodine on it. A blue color indicates that starch is present.

What was observed: How many samples contain starch? If you have starch in your mouth by brushing your teeth, does the brushing really clean the teeth?

What was learned: How can you test tooth paste for starch? Does absence of starch in tooth paste prove it is good?

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

The United States —1— tests materials for the government. The most frequently imitated furniture wood is —2—. The consumer is likely to get the best advice from —3—. An expensive wood glued over a cheaper wood is called a

—4—. Advertisers' tests are generally —5— reliable. Wool mixed with —6— is of a poorer quality than pure wool. The —7— Act is designed to protect us against harm from certain things sold in several states. The word "Guaranteed" in an advertisement means —8—.

A review of the chapter

We buy not only to satisfy our actual needs for food, clothing and shelter, but also to satisfy emotional needs. Advertising, which is a method of persuading the consumer to buy, appeals more often to the emotions than to the intelligence. The consumer needs accurate scientific information about a great variety of goods and can best obtain this information by using the services of a consumer organization.

All buying should be planned in advance by use of a budget to insure caring for all essential needs, and to avoid buying according to whim. It is best to pay cash, to avoid the additional charges added to installment prices.

The wise buyer learns to detect meaningless phrases, misleading advertising, and unsound claims of scientific approval of goods. Instead, he seeks actual facts about the articles he wishes to buy, compares prices of various articles, and usually buys the cheapest article which seems the most satisfactory for his use.

Many excellent new products are being developed. However, the buyer needs to be cautious in purchasing untried and untested goods. Our standard of living is raised by wise buying.

Word list for study

Be sure that you can pronounce, spell, define, and use in a sentence every word in this list. Each of these words has been defined or explained and used in this chapter.

psychologist	masculine	adequate
inferior	advertising	design
style	fashion	copyright
emotion	slogan	endorsement
budget	impulse	quality
annealed	alloy	magnesium
consumer	photoelectric	veneer

An exercise in thinking

Below are two groups of sentences. The first group contains principles, which are large general ideas. Each sentence in the second group contains an idea related in some way to one of the principles in the first group. Write the numbers from 1 to 32 on a piece of paper or in your notebook. Find the principle which best explains the idea in the second list. Then after the number on your paper write the letter before the related principle.

List of principles

A. The relation between price and quality is low.

B. The first consideration in buying is to satisfy basic health needs for food, clothing, and shelter.

C. Many things are bought to satisfy emotional desires.

D. Mass production is the economical production of many objects exactly alike by use of machines.

E. The best way to discover facts is by experiment.

F. There is no important relation between quality and amount of advertising or newness of style.

G. There is a minimum price below which a satisfactory article cannot be produced.

List of related ideas

1. A man's $25.00 suit was made of stronger cloth than was a $65.00 suit.
2. One manufacturer produced both the best and the worst towels tested.
3. Automobiles cost less than they did 50 years ago and are much better.
4. The budget should first provide for an adequate diet.
5. Poor students often start fads in clothing.
6. Modern plastics have been developed by research.
7. Stylish shoes are often of poor quality.
8. It is a waste of money to buy a dollar field glass.
9. Many people are undernourished because of poor buying habits.
10. Low price is impossible without using advertising to sell manufactured goods.
11. Alcoholic liquors are sold by advertisements showing people in luxurious surroundings.
12. A cooking fat advertised to be pure vegetable oil was found to contain mineral oil.
13. Any part of a given model of an automobile can be changed for the same part of the same model and will serve perfectly.
14. Cloth advertised as all wool was 40 per cent cotton.
15. Clothing should be selected for quality and comfort before style.
16. One manufacturer sold the same make of dry cell under different labels at considerably different prices.
17. Lard produced locally is usually a better cooking fat than a manufactured fat sold under a trade name.
18. Many women wear unbecoming hats to be in style.

19. Hamburger sold at very low prices often contains corn meal or some cheaper substitute.
20. It is easier to obtain repairs for well-made American watches than for handmade European watches.
21. You cannot buy a good-quality all-wool blanket for three dollars.
22. Four-dollar shoes often wear as well as ten-dollar shoes.
23. Milk is a good buy on the average family budget.
24. The most widely advertised razor blades are not the sharpest.
25. Seeing a new radio in a neighbor's house makes us want one.
26. Most eighth-grade girls experiment with use of lipstick.
27. Durability of shoes is tested on a "walking machine."
28. Some lower-cost automobiles give less trouble than do other more expensive makes.
29. The great improvement in refrigerators has resulted from constant experiments to find better machinery and materials.
30. A fifteen-cent camera is a device for wasting film.
31. Advertisers usually do not appeal to our intelligence.
32. A wise consumer does not buy alcohol or tobacco.

Some things to explain

1. Is it enough that advertising should contain no falsehoods? Can advertisers afford to tell the truth, the whole truth, and nothing but the truth?
2. How does advertising add to the cost of goods?
3. How does advertising lower the cost of goods by making possible mass production?
4. What are the advantages of using a budget in purchasing?
5. How can you learn what foods are pure and nourishing?
6. From the consumer's point of view, state which of these high school courses are of value: chemistry; cooking; algebra; wood shop; general science; newswriting; Latin.
7. Learn what type of store has the highest selling cost.

Some good books to read

Brindze, R., *How To Spend Money*
Eaton, J., *Behind the Show Window*
Gaer, J., *Consumers All*
Jacobson, D. H., *Our Interests as Consumers*
Kallett, A. and Schlink, F. J., *100,000,000 Guinea Pigs*
Ludwig, L., *Do You Know What You Are Buying?*
Pryor, W. C. and Pryor, H. S., *Let's Look at Advertising*
Trilling, M. B. and Nichols, F. W., *You and Your Money*

CHAPTER

8

Selection of Suitable Clothing

Boys and girls begin to be more conscious of their clothing as they grow into maturity. Clothing is one of the means we have of expressing our individuality. A person well adjusted to fit into his group will wear neat and attractive clothing of the style approved by the group. The person who does not fit well into the group is more likely to wear unsuitable clothing. You are familiar with the girl who wears extreme styles and is a little loud and uncertain socially. There is the boy who lives in a dream world and wears cowboy clothing when it is not appropriate. There are boys and girls who wear old, poorly cared-for clothes in an attempt to conceal their failure to feel adequate. By accepting the higher standards of your social group in choosing clothing, you can help to make yourself feel adequate.

Clothing also has many practical uses. It should keep you warm in winter, and should protect you against extreme heat in summer. It should be chosen to fit the occasion. When you are in the woods, your legs should be protected against scratches from bushes, poisoning from weeds, and bites of insects. When you are downtown, you should be dressed in good taste according to grown-up standards. On the playground you need clothing that is as light and comfortable as is acceptable where you live.

The amount of service that you get from clothing depends partly upon the way it is made and partly upon the kind of cloth used in its construction.

Can you develop enough judgment of the important things that must be considered in buying clothing to select your own clothes wisely?

Some activities to do

1. Collect samples of many kinds of new cloth. Make three strips of equal size from each sample. Put one away in the dark for a control. Fasten one on a board which you can leave

outdoors in sun and rain for several days. Wash the third strip in strong soapsuds. At the end of two weeks compare the samples for color, feel, and size.

2. Go window shopping or look through advertisements and classify garments advertised as (1) entirely suitable for the use recommended; (2) stylish but not particularly suitable; or (3) so unsuitable that they may injure the health.

3. Do you think that your school is ready for the style of being sensible? How would you start a "Good sense in clothing" campaign to discourage wasting money on fads?

4. Make a collection of cloth fibers or of cloth samples. Put them on a cardboard to display them. Label them correctly. When in doubt use the simple tests you have learned to help in making a decision.

5. Obtain one white shoe and one black shoe. On a very hot day wear them at the same time while walking in the sunshine. Note which foot feels warmer.

6. Grasp your left wrist firmly with your right hand, and squeeze it for a minute or two. Note the appearance of the veins and how the hand feels. How would tight clothing affect circulation?

7. Obtain three pairs of shoestrings of different kinds. Find a way of pulling on one string of each pair until it breaks and thus find its breaking strength. Then attach a 5-pound weight to the other string and pull it over the edge of a file 50 times. Test its breaking strength.

8. In your community visit any factory which produces cloth, clothing, or chemicals related to clothing.

Coker Pedigree Seed Company

Cotton is the most important natural cloth fiber. The cotton fibers have been improved by selecting the best cotton plants for seed.

Some subjects for reports

1. The methods of manufacturing new synthetic fibers

2. Fur farming and advantages of farm-grown furs

3. True and trade names of furs

4. How cloth is dyed and printed

5. Types of leather used in different kinds of clothing

6. Methods of manufacturing gloves and mittens

7. How knitting and weaving are done by machines

8. Fireproofing fabrics for home use by simple methods

9. Clothing styles of ancient and recent times

10. Cost of complete clothing outfits for school, for camp, for work and play, and for different seasons

1. What natural materials are used for clothing?

Perhaps the first clothing worn by man was used for ornament, and had no value as clothing at all. But when men began to move into cold climates, they used the skins of animals for protection from the cold. Since those long-forgotten days men have improved their condition in many ways, and not the least of these is in materials for making clothing.

How is cotton used for clothing? Cotton is a fiber taken from the boll [bōl] of a plant that probably was first grown in eastern Asia. The cotton boll is a fruit of the cotton plant. To obtain the fibers they must be separated from the seeds. The cotton gin was invented by Whitney for that purpose. The long fibers are used for making cloth, and the short fibers are used for making waste, rayon, and cellophane.

The cotton fibers are first untangled, then twisted together to make threads, which are in turn knit or woven into cloth. There is a great variety of ways of making cloth. Jersey is knit. Broadcloth, homespun, twill, and basket weave show some of the ways fibers are woven to produce different effects.

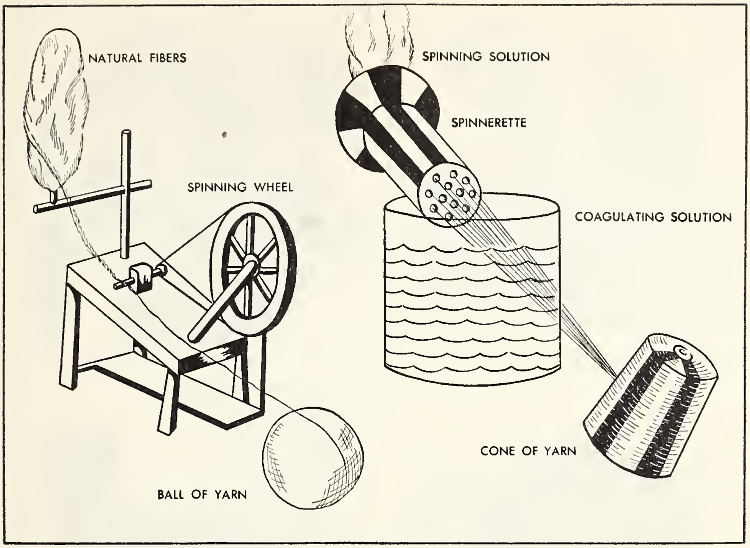
Cotton is strong, and is resistant to harmful action of soaps and other chemicals. While it is not as warm as wool, when tightly woven it is useful for protection against the wind, and is often used for that purpose in work clothes and snow suits. It is possible to weave cotton so loose and thin that it is one of the coolest cloths. Cotton is still the most important single cloth fiber. Its use for underwear, shirts, gloves, stockings, work clothes, play suits, house dresses, handkerchiefs, and shoelaces is known to all of you.

Cotton absorbs moisture rapidly, but does not dry well. It is therefore not good to use in swimming suits or in sports jerseys.

How is wool used for clothing? Wool is the hair of sheep. It is removed by clipping it from the animals early in the spring. It must be cleaned, either by washing or by other means, to remove grease, burrs, dirt, and parts of plants. After this, it is spun and woven in about the same way as is cotton.

Wool which is used for the first time in clothing is sometimes called virgin wool. Most wool clothing is made wholly or in part from re-used fibers. That is, an old garment will be torn into fibers by a machine, and the broken fibers will be used again. Wool fibers may be used half a dozen or more times, each time becoming weaker, shorter, and less attractive in appearance.

A particularly important property of wool is its ability to hold air when it is woven. Small air bubbles cling to the fibers. The fibers are also springy, and keep



Drawn from American Viscose Corporation diagram

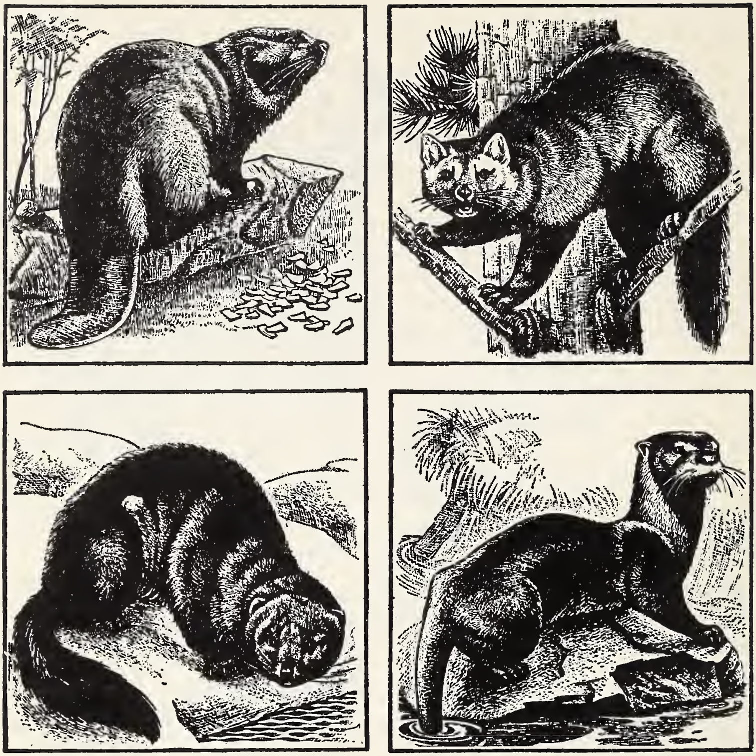
The old-fashioned spinning wheel made it possible to twist natural fibers into a thread. The modern chemically produced fibers are also spun by a machine which twists them into thread.

small spaces between them when made into cloth. In these spaces air serves as an insulator. While all cloth fibers are poor conductors of heat, wool is one of the poorest. Wool is used for winter clothing of all kinds: overcoats, sports suits, caps, mittens, sweaters, and work clothing. Wool is not a good windbreak unless it is woven very tightly. But tightly woven wool is a poor insulator. An excellent inexpensive combination of outer clothing for keeping the body warm is a heavy canvas, duck, or gabardine coat with an attached hood, worn over a knit wool cap and sweater.

Because wool drains and dries rapidly, it makes good swimming suits. It is the best material for sports socks, for it protects the feet against friction and permits rapid evaporation of perspiration, thus keeping the feet cool.

Is linen used for clothing? Linen is the cloth made from fibers of the flax plant. So little linen is used for clothing that it would not deserve mention except that many people call some cloth "linen," when really it is made of cotton or other fiber.

How is silk used for clothing? Silk is obtained by unwinding the fiber of the cocoon of the silkworm caterpillar. This caterpillar feeds on the leaves of the mulberry tree. When the cocoon is spun, the caterpillar is heated and killed. The fiber is unwound by hand.



Rudolf Freund

The beaver and marten (*top*) and the mink and otter are bearers of luxury furs.

Silk is the most beautiful natural fiber. It has a shiny appearance, and can be woven into fine cloth. It is exceptionally strong, and if not weakened by chemical treatment is durable. Silk cloth feels soft. Some silk is used in making women's stockings. Because of the need for making the stockings thin, and because there is no way of knitting a stocking that will not run, they generally are discarded while most of the fibers are still unbroken. Silk is also used for expensive undergarments, dresses, shirts, and neckties.

How is leather made into clothing? While the skin of any mammal can be made into leather, the most common leather comes from cattle. To make leather, the hide is freed of hair, fat, and flesh. It is soaked in a cleaning solution, then treated with one of a number of chemicals to make it soft and flexible. The hide is usually split, for natural cowhide is too thick for most uses except shoe

soles. The outer layer is of good quality. The inner layer is porous and weak. The skin from some parts of the animal is stronger than that from other parts.

The best-quality leather is made into good shoes. Other leather is used for gloves, cheap shoes, jackets, and caps. Sheepskin is frequently used for making jackets, which are warm and useful as windbreaks. Fine jackets are made from horsehide. The skin of young goats, called kid, is used for expensive gloves. Calfskin is used in dress shoes. Some reptile skins are used for novelty shoes, belts, and ornaments.

Is fur used for clothing? Four animals—muskrat, rabbit, skunk, and opposum—provide more fur than do all other animals. Yet we rarely see furs advertised under these names.

Most fur is dyed to give it the appearance of being a more expensive kind. Rabbit may be sold as sealskin or mink when properly treated. Honest furriers give the correct name of the fur, but do not usually place emphasis on it.

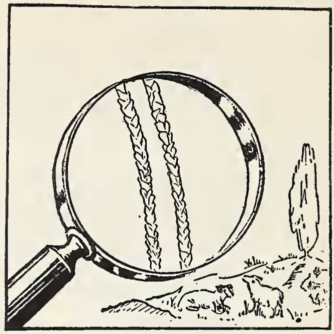
In most parts of the United States there is no reason for the use of fur in clothing. Because most fur is too weak to be of value for work or sports clothes, it is used chiefly as a luxury material for women's coats. The care of fur coats is expensive. Fur has the advantage of being light in weight and quite warm. Fur is a good insulator because the spaces between the hairs hold air well. The more durable furs are used for protection from cold in the far North.

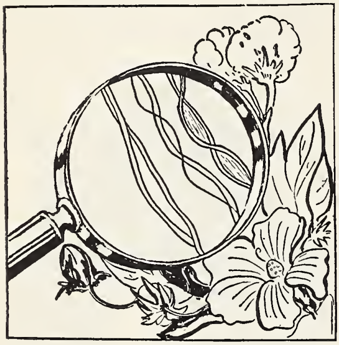
Sheepskin with the wool left on it is used for lining snow suits, overcoats, and work coats, and is a better buy for the money than is a fur coat. It is as warm, lasts longer, and costs much less. Sheepskin leather linings may be put into heavy wool coats for warmth.

An attractive and durable fur is made from sheepskin. The fibers are treated with a plastic-type chemical which makes them less kinky, makes them softer, and gives them a sheen. The wool fur can be dyed any desired color. This fur can be produced more cheaply than most other furs, and is more durable than most.

How are cloth fibers identified? There are a number of simple tests of some value in identifying cloth fibers. One of the best tests is to examine them through a microscope. Not only can the different fibers be recognized, but broken and re-used fibers may be detected. Cloth fibers under the microscope have the appearance shown in the diagrams.

Silk and wool are animal fibers, and for this reason will respond to the protein test. Protein is found in almost all animal tissues. It is also a kind of food. To test for protein, the sample is heated gently with nitric acid. A protein will turn yellow. If, upon rinsing off the acid and putting





Three important natural fibers are silk (*top left*), which is smooth and shiny; wool (*top right*), composed of overlapping scales; and cotton (*left*) which is flat and twisted.

ammonia upon the sample, it turns a deep yellow, the material is certainly protein. Cotton and rayon, being made of vegetable materials, will not respond to this test.

A wool-and-cotton-mixed sample may be detected by boiling the cloth in a strong lye solution. The wool dissolves, the fat of the wool combining with the lye to form a soap. The cotton is left behind. Silk dissolves fairly fast in hot hydrochloric acid, but so do some man-made fibers.

DEMONSTRATION: HOW ARE SILK AND WOOL RECOGNIZED BY CHEMICAL TESTS?

What to use: Cloth samples, lye, nitric acid, ammonia, test tube, holder, burner.

What to do: Test the samples as described in the text. (*Use extreme care in handling these chemicals. Lye is capable of producing dangerous burns. Since your skin and flesh are protein, you can be turned yellow by chemicals used in this test, besides being badly burned. Wash all chemicals into the sink drain with cold water.*)

What was observed: Describe briefly what happened to each sample. Could you see soapsuds at any time during the test?

What was learned: Is wool a kind of chemical different from cotton? What is the difference in the appearance of the samples that contained silk or wool and those that did not?

Things to think about

Match the following subjects and predicates. Copy the sentences in your notebook.

Subjects

1. Cotton	6. Lye
2. Wool	7. Wool fiber
3. Silk	8. Virgin wool
4. Fur	9. Cotton fiber
5. Linen	10. The boll

Predicates

A. is used to dissolve wool in testing cloth samples.
B. looks scaly, and holds tiny air bubbles, when viewed through the microscope.
C. is obtained from the cocoon of a caterpillar.
D. is the cheapest and most common cloth fiber.
E. is the fruit of the cotton plant.
F. is rarely sold under its true name.
G. is used in making the warmest economical clothing.
H. has not been used before.
I. looks twisted when seen under the microscope.
J. is rarely used for clothing today.

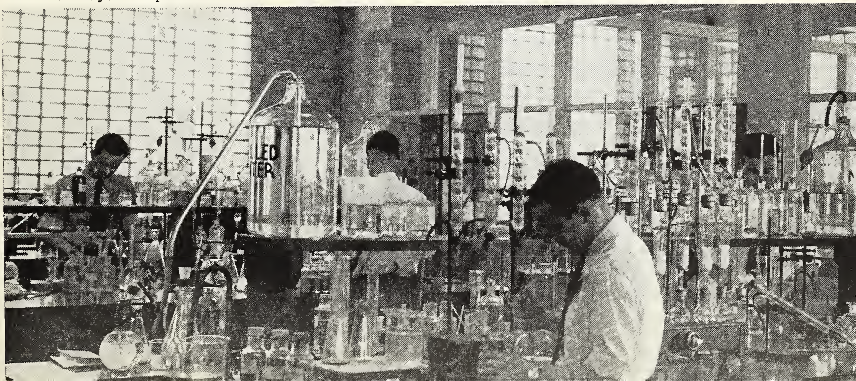
2. What are the common synthetic fibers?

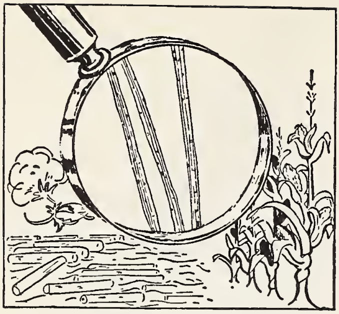
No longer is man dependent upon natural fibers for his clothing. The chemists today are able to make from common chemicals fibers that are able to rival any produced naturally. The correct name for this group of materials is synthetic [sĭn-thĕt′ĭk] fibers. The word *synthetic* means "put together," or "built up." This is just what men do when they make new fibers. Making synthetic fibers is a chemical change.

What is rayon? There are several ways of making rayon. The raw material used is cellulose [sĕl′ů-lōs], which may be obtained from wood, cotton, or stems of various plants. To make rayon from wood, the wood is chopped into chips. These chips are dissolved in chemicals until they become a sirupy liquid. Then this liquid is forced

Making artificial fibers is a chemical process. Chemists constantly test and check the solutions used in making the rayon yarns produced in this plant.

Industrial Rayon Corporation





Rayon fibers are smooth, straight, and round and may be filled with tiny bubbles.

through a metal plate full of tiny holes. As the liquid flows from the holes, it runs into another tank of chemicals which causes the tiny streams of liquid to harden into a fiber. The fibers may be further treated to give them a special appearance or to give them extra strength.

Rayon has an advantage over silk in that it can be made into fibers of any length desired, and will take dyes of some types that will not blend uniformly in silk. Rayon was originally intended to replace silk, but it has many uses of its own. Rayon is used in making many kinds of dresses, some of which resemble wool, some linen, and some silk. Most women's and much of men's underwear is made of rayon. Rayon is sometimes mixed with wool, for it is harder to detect than cotton. Rayon is also used for fabrics other than clothing. One use is for making cords in automobile tires.

What are other silklike fibers? One of the new synthetic fibers has been named nylon by its producers. This fiber is made from materials taken from coal, air, and water. Of course not all the chemicals in these materials are used. There are several chemicals in coal which may be used to produce cloth fibers. Nylon can also be made from corn cobs. A bushel of cobs will yield 40 pairs of stockings.

The success of making nylon depends upon causing the molecules to stick tightly to each other in chains. By making them stick together, the molecules become tangled in such a way that they form very tough fibers.

The fibers are produced by machinery and processes of manufacture similar to those used in making rayon. Nylon is as strong as silk, and can be made into threads finer than silk. It is used in making stockings, underwear, dresses, neckties, and many other articles. Nylon stockings are better in some ways than those made of silk. Nylon can be pressed to hold its shape without repressing; yet it is elastic. By producing nylon according to a slightly different process, it may be made to resemble wool, and it is about as good an insulator. To make them resemble wool, the fibers are crimped [made wavy] by a machine as they are formed.

Nylon is used also in thicker fibers for toothbrush bristles.

Vinyon, another silklike fiber, has similar properties. It is made from materials taken from salt, coal, lime, and air. It is useful for making stockings, waterproof

bathing suits, and other silklike articles. Because it resists acids, it is useful for clothing in chemical industries.

What fibers resemble wool? One of the most intense searches for an artificial fiber has been for one that will replace wool satisfactorily. One such material is made from milk. As you know, wool is a protein chemical. Milk contains a protein, casein [kā′ sē-ĭn], which is made from milk curd [solids]. To obtain the curd, an acid is used to make the milk separate. None of the milk is wasted, for the butterfat is used for food, and the liquid part of the milk is fed to pigs.

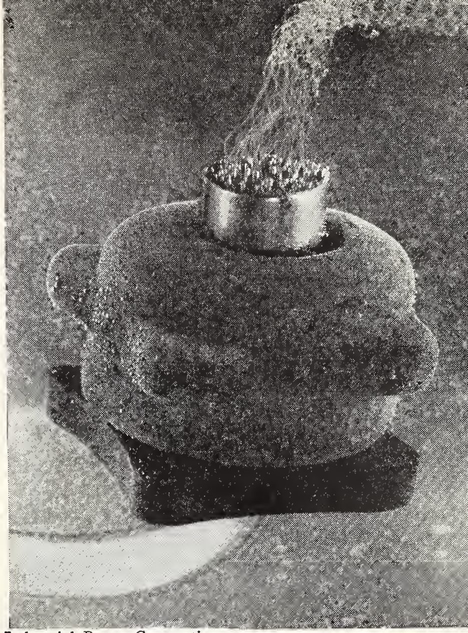
The casein is dissolved, and the sirupy fluid is forced through holes in metal plates, just as rayon is. The cost of casein needed for fibers for a man's suit would be about fifty cents. The cost of manufacturing is much greater than this, of course. The resulting synthetic wool resembles real wool so much that it is difficult to tell the difference. It is about as strong as wool, and takes dye in a similar way. You might be able to detect the difference by burning a sample, for real wool contains much more sulphur than the artificial wool and burns with a different odor.

Casein is also used to make most of the common white buttons used on shirts and similar garments.

A synthetic wool may be made from proteins from fish, or from soya beans.

Is rubber used in clothing? You are familiar with the rubber used in erasers and overshoes. It is made from the sap of a tree originally found in South America, and it is treated with sulphur to make it tough and stretchy.

To make use of the rubber in garments, the now-familiar process of making fibers is used. Then around each fiber are placed fibers of some other material—cotton, rayon, or silk—in such a way that they and the rubber form a single, stretchy thread. This rubber thread may then be woven like any other. It is used in making women's undergar-



Industrial Rayon Corporation

"Liquid rayon" is changed into fibers as it is discharged through the tiny holes of this platinum spinneret. The liquid in which the filaments are floating hardens them into fibers.

ments, swimming suits, stocking tops, and other garments where stretch is important.

What are some other synthetic fibers? Metal fibers are sometimes used in cloth for decoration and for formal dresses. Glass is made into a fiber which can be spun into cloth. Neither metal nor glass fibers promise much for use as clothing, however. Glass fiber is used in making fireproof curtains and for wrapping wire carrying electricity. Metal is woven into cloth for sifting face powder.

How are common fibers improved? Perhaps you have upholstery on furniture or a tablecloth which can be wiped with a damp cloth. It may be made of cotton fibers coated with plastic. Thin cotton materials, such as organdy and voile, coated with cellulose—the stuff of which rayon and cellophane are made, are used in making lightweight summer dresses. This cloth does not wilt when the wearer is warm. A heavier cotton material so treated is used in making laboratory clothing. This treatment reduces the amount of lint given off in clothing, an important item in laboratories where lint may spoil important work.

Treatment of cloth to make starching unnecessary is being worked out fairly satisfactorily. Other processes have been worked out to reduce the amount of shrinkage of wool, and to reduce shrinkage of cotton to a very small amount.

Should you use new fibers? When you buy cloth made of a new fiber, do not expect miracles. Before any process can be made completely successful, there must be a period of experimenting. Often things that seem satisfactory in the laboratory need further development when tried out by customers. For example, shirt collars which do not need starch have not always been successful, for the stiffening material washes or melts out of the collar in spots. Unless you can afford to lose money, do not rush to buy a new material. It may be better than any product of its kind ever offered for sale, or it may be a mistake which will disappear from the market in a few months.

A few of the new materials offered for sale have proved irritating to people's skins. Garters and wristbands made of artificial materials have caused rashes. Other materials advertised to make shoe linings antiseptic [ăn′tĭ·sep′tĭk, free from germs] have been proved to be semipoisonous. The price of progress is experimentation. Do you want to pay the price, or let others do it?

DEMONSTRATION: HOW DOES RAYON RESPOND TO TESTS?

What to use: Hydrochloric acid, lye, nitric acid, ammonia, test tube, holder, burner.

What to do: Test the rayon sample as explained in the problem before this. If other synthetic fabrics are available, test them too.

What was observed: Does rayon contain protein? Does it dissolve readily in lye and acid?

What was learned: Is there any certain way of knowing if a sample is rayon, and not silk or wool?

Things to think about

Copy the following sentences in your notebook. Select the correct ending for each sentence.

1. Any material which is made by putting together molecules of other materials is (*a*) casein (*b*) synthetic (*c*) vinyon.
2. Coal, air, and water provide materials for making (*a*) nylon (*b*) rayon (*c*) artificial wool.
3. Cellulose is used for making (*a*) rayon (*b*) nylon (*c*) vinyon.
4. Casein is used in making (*a*) nylon (*b*) vinyon (*c*) artificial wool.
5. After the dissolved synthetic material is forced through holes in a metal plate, it goes into a liquid which causes it to (*a*) shrink (*b*) become stronger (*c*) harden.
6. The long fibers of synthetic cloths make them (*a*) brighter in color (*b*) stronger (*c*) faster drying.
7. Casein is a protein found in (*a*) milk (*b*) wood (*c*) coal.
8. Cotton coated with cellulose is less likely to (*a*) run (*b*) wilt (*c*) wash well.

3. Can clothing affect our health?

There are many reasons for wearing clothing. One of the first uses of clothing by primitive man was for decoration. We have developed ways of living together that require the use of at least a small amount of clothing for the sake of modesty. We use clothes to satisfy emotional urges, to conceal physical weaknesses, to show that we fit into social groups, and, most important, for protection.

How does clothing keep us warm? The most important single use of clothing is to regulate body temperature. We lose heat by evaporation of perspiration, by contact with cold air, and by radiation of heat from the skin.

The entire body needs protection to keep wind from striking it with too much force. Per-

The selection of clothing for play and sports depends upon style, climate, and personal taste. Three common combinations of suitable sports clothing are worn by these girls.

Minneapolis Board of Park Commissioners

Bituminous Coal Institute

This young woman is dressed in rain clothing made of plastic and holds a plastic-covered umbrella. Samples of other waterproof plastic materials are shown in the background.

spiration evaporates rapidly in a breeze, and chilling of the body results. Being chilled makes one more likely to catch cold. It also causes stiffness of the muscles. If one should be catching a dangerous disease, such as polio or rheumatic fever, chilling might cause permanent crippling or death. If we are indoors and not sitting directly before an open window or ventilator, ordinary clothing provides all the protection needed against drafts of drying air. Out of doors, however, the clothing needed depends entirely upon the speed of the wind and the temperature of the air.

If clothing becomes wet from rain or snow, severe chilling may result, for the heat of the body is used to evaporate the water from the wet clothing. A large amount of heat is required to evaporate a small amount of water. Consequently the heat-producing ability of the body is unable to evaporate the water and at the same time keep the body warm enough for health. In regions where there is rain during the cold season, rubbers, waterproof coats, and caps or hoods are desirable. Very attractive rain clothes are sold today for reasonable prices. They may be made either of rubber or of waterproof synthetic materials.

In extreme cold weather we need protection from being chilled and from actual freezing. Each year many people die from exposure, and a few immediately from freezing. Frozen fingers, toes, ears, and cheeks are not uncommon in the northern states.

Several important facts about keeping warm have been learned recently. One is that the outer garment should serve as a windbreak. A lightweight, tightly woven cotton treated to make it water resistant is best. Underneath this garment any good insulating clothing may be worn. Knit wool, cotton or wool-fleeced garments, or fur may be used. Several layers of garments are better than an equal weight of cloth knit into one layer of heavy cloth.

For work or sport, denim, poplin, or twill cotton jackets and pants worn over wool sweaters and slacks are excellent. Girls

may wear cotton slacks over loosely knit wool clothing for warmth in extreme cold.

If heavy outdoor clothing is worn, it should be removed indoors to prevent becoming unhealthfully warm. If a coat has an attached hood, such as the Eskimos wear, it gives the head and neck needed protection. Really good clothing of this type is now being produced at costs much below the price of a good all-wool dress coat.

Extra heavy cotton underwear is usually worn for outdoor sports. But, if you are going to be out of doors in the cold all day, wool underwear provides the best and most convenient means of keeping warm. It is inexpensive and comfortable to wear. It should not be worn indoors, however.

The ears need protection, not only from freezing, but to protect hearing. Chilling the ear may lead to infection which destroys the organs of hearing. Going without a hat or cap on cold days is not smart.

Rubber, fleece-lined overshoes are the best winter protection for the feet. They should be worn over ordinary shoes and not in place of leather shoes. Most boys and girls know enough to wear warm mittens if they have them. Two or more pairs of lightweight socks are warmer than one heavy pair. Shoes should be large enough to avoid tightness, for tight shoes reduce circulation and leave little room for dead air spaces.

How does clothing protect us against heat and sunshine? Summer clothing must be as light in weight as possible to permit circulation of air against the skin. Yet it should protect us from too much air movement. Summer clothing must absorb perspiration and permit it to evaporate fairly rapidly. Loosely woven cotton and knit rayon have advantages over most other fabrics for this purpose. The sun not only causes us to be uncomfortably warm in summer, but it also may cause severe burning if the skin is suddenly exposed without being tanned. In the sunny sections of the United States many children become so deeply tanned that the skin is permanently coarsened and roughened. Too much sun is harmful to the skin.

People whose skins have been exposed for a long time to sunshine are more likely than the average to have skin cancers.

Ultraviolet energy from the sun is particularly harmful to the eyes. It causes redness and soreness of the eyes. There is a loss of acute vision for perhaps two or three days after overexposure to ultraviolet light.

A suitable hat with a brim is needed to protect the eyes, head, and face. Straw and synthetic strawlike materials make the best summer hats. They should be loosely woven to permit circulation of air. Many people suffer sunstroke from too much exposure to the sun.

Hats also offer protection to the eyes. Wearing sunglasses and

Bituminous Coal Institute

Before being washed the two wool dresses were the same size. The one worn by the girl has been treated to prevent shrinkage. The one on the doll was untreated and shrank badly. Do you enjoy having your clothes fit?

going bareheaded in the sun are fads that are not based on sound experience. Colored glasses may cause eyestrain, and offer no protection to glare around their edges.

What clothing should we wear indoors? If the temperature indoors is 68 degrees, we need light wool or heavy cotton outer clothing which protects the arms. Our underclothing should be of cotton or rayon. In the northern states it is wise for boys to wear underclothing that protects the legs. After girls reach the age of about 13, they do not require quite as heavy clothing as do boys, because beneath a girl's skin there develops a thin layer of fat that protects somewhat against cooling. Boys and underweight girls lack this fat layer, and need warmer clothing.

Boys should not wear heavy wool sweaters indoors. Suits or light sweaters or jackets and wool trousers are satisfactory. To protect the arms, girls should wear light sweaters or heavy blouses or dresses with sleeves.

In winter girls should wear long stockings with short socks over them. The socks not only protect the feet from cold, but provide more protection against rubbing by the shoes than do thin stockings.

If the indoor temperature is about 75 degrees Fahrenheit, we should dress very lightly. At temperatures above 85 degrees lightweight clothing absorbs perspiration and prevents chilling in breezes.

Does clothing affect mental health? You have probably worn some kind of clothing that made you feel very much out of place. Perhaps you went to a picnic dressed in your dress-up clothes, while all the others wore sports clothing. Perhaps you bought a garment which proved to be too conspicuous and loud for school wear, and as a result you acted silly in every class. Your clothing, then, may make a difference in the way you feel in the presence of other people.

There are two things you can do to become well adjusted in wearing clothing. One is to choose clothing that is suitable for the occasion and to wear it. Clothing should be neat and in the best possible order. The other thing you can do is to develop the ability to forget yourself. You are noticed much more if you act silly and embarrassed than if you act as if you were self-confident. If you immediately enter into whatever is going on, taking your proper place, you can soon forget clothing that is accidentally torn or dirty, or of poor selection.

Some children try to impress other children with their own self-importance by criticising the clothing and appearance of others. The child who does the criticising is often the one who has something wrong, and not the one who is criticised. When girls get together and discuss the faults of others, they are showing their own feelings of inadequacy. Emotionally and mentally mature people do not spend their time trying to find fault.

Why should we avoid tight clothing? Tight clothing tends to slow circulation of the blood, and may cause displacement of organs of the body. Tight belts, girdles, and garter belts may press the intestines out of position and may cause poor circulation in these important organs.

Tight garters may interfere with circulation of the blood to the legs and feet, causing strain upon the veins and making the feet cold. When the weather is warm enough, it is best to wear short socks that do not require garters. There is no really satisfactory way of supporting girls' stockings, but a garter belt, fitted as loosely as possible, probably will not cause too much harm. Boys should wear suspenders instead of belts.

Foundation garments recommended to girls are likely to cause unnecessary pressure. The best foundation for any garment is a healthy body, protected with muscles developed by exercise, good food, and rest. Healthy girls do not need such garments, and unhealthy ones will be made still less healthy by their use.

DEMONSTRATION: HOW FAST IS HEAT CONDUCTED BY CLOTH?

What to use: Three tin cans of the same size, one piece of wool, and two pieces of cotton cloth large enough to wrap the cans, boiling water, thermometer, wood or asbestos mat covers for cans.

What to do: Wrap one can in wool, and two in cotton. Wet the cotton on one can and keep it wet. At the beginning of the period fill all three with boiling water, and quickly cover them with the boards or asbestos. At intervals of 10 minutes take the temperature of the water in each can, keeping the cans covered as much as possible.

What was observed: Make a table of the temperature readings.

What was learned: What is the best condition for keeping heat from being lost? The worst? Why?

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

—1— of perspiration cools the body. Chilling makes one more likely to suffer from —2—. Heat from the body is used to —3— water from wet clothing. Cotton in a snow suit serves as a —4—, while wool or sheepskin provides an —5— material to prevent heat loss. Exposure of the ears may result in reduced ability to —6—. Continued sunburn makes the skin permanently —7—. The eyes should be protected by some kind of —8—. Tight shoes or clothing may —9— the bones of the body and interfere with —10—.

4. Do shoes affect our health?

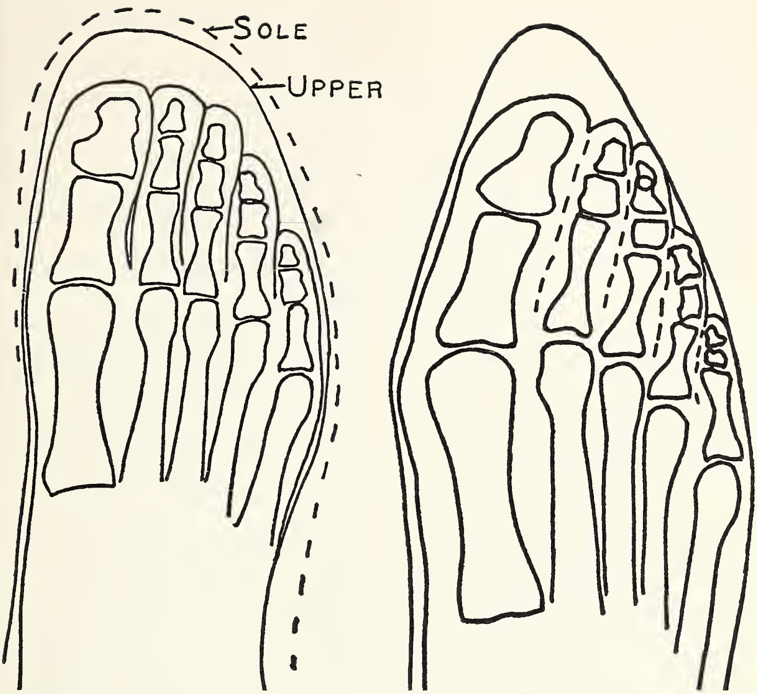
If you were asked to name the greatest cause of discomfort and suffering, you might think of some deadly disease, or even the common cold or toothache. But actually more people suffer from aching and painful feet than from any other cause. A large study showed that 70 per cent of people have foot troubles. And foot troubles are largely shoe troubles.

What are some common foot troubles? Callouses on the feet indicate either rubbing or too much pressure on the skin. Corns result from the same condition having existed for a longer time. Blisters are common results of friction of shoes or stockings against tender skin. Blisters often become infected. An ingrown toenail results when the flesh of the toe is pressed against the edge of the toenail.

Several foot troubles are actually deformities. A bunion is a displacement of the joint of the large toe. It is usually caused by wearing a narrow shoe which pushes the large toe inward. There is a pad of cartilege [kär′tĭ-lĭj, the elastic material in the skeleton] in the space between the bones. Sometimes it becomes permanently inflamed by pressure on the toe joint. Deformed toes are not uncommon. As a result of wearing short shoes or stockings the bone in the toe-tip is pushed backward, and may slip out of its place in the joint.

The best-known foot deformity is the fallen arch. There are five long bones that make up the support of the front part of the foot. When one or more of these bones slips from its joint because of injury or pressure, it may not return to its place. These bones may slip off to the side of the foot, causing a spread in the middle of the foot.

Athlete's foot is a fungous disease of the skin. It can be prevented only in part by proper shoes, since it is infectious. If a shoe is broad enough to let the toes separate and have space, it is easier to cure athlete's foot. Shoes which cause undue perspiration are favorable to the growth of the fungus. Fatigue and bad temper are frequently results of poorly fitted shoes and foot trouble. Aching feet may



Consumers' Research, Inc., Washington, N. J.

The drawings are made from X-ray photographs of a foot properly fitted (*left*) and one not properly fitted. Note that the pointed shoe causes bending of toes at joints, overlapping of toes, and crowding and pressure on the foot.

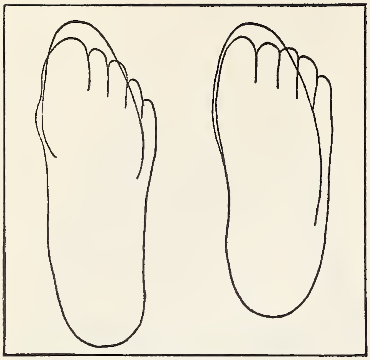
cause digestive upsets, backaches, and headaches.

What kinds of shoes are common? Shoes may be divided roughly into two groups, useful or work and play shoes, and decorative or dress shoes. While not nearly all useful shoes are good for the feet, it may be safely said that almost no dress shoes are really good for foot health.

A useful shoe has a low, sturdy, wide heel, and is generally rather broad. It may be made of various materials, but always follows the natural shape of the foot if prop-

A comfortable, well-fitted shoe may still have decorative parts added. This style of shoe is sound and healthful.

U .S. Bureau of Home Economics



Consumer's Research, Washington, N. J.

These outlines of the toes of feet and of shoes show that often shoes do not fit the feet on which they are worn.

erly made and fitted. Not nearly all useful shoes are well made.

Dress shoes are of less sturdy construction. Women's and girl's dress shoes are likely to have high, narrow heels. They may consist of only a few straps or cords, or may be made of weak materials such as straw or colored plastic. Pumps must always be considered dress shoes. Open toes and heels are typical of dress shoes. Wedgies are dress shoes, because they are not flexible enough to bend with the foot. Boy's and men's dress shoes tend to have pointed toes, and to be made with extra layers of decorative leather. Patent leather shoes are always dress shoes.

A dress shoe should be worn only when one will not walk far in it, nor be required to stand in it for any length of time. If properly fitted a dress shoe may be safely worn for an automobile ride or to a movie. Dress shoes commonly worn for dancing produce blisters on the feet, and start the deforming of the bones of the feet. No girl should ever wear a dress shoe to school, around the house, or to work.

The work or useful shoe should always fasten with laces or with straps that can be adjusted to the individual foot. It will support the foot snugly around the heel and arch, and will give the rest of the foot room to spread. Whether it should be a low or oxford type shoe, an ankle-height shoe, or a boot depends upon need. For indoor wear a low shoe is best and is commonly worn.

How should shoes be fitted? You cannot depend upon the average shoe salesman to fit your foot. He is interested in pleasing your eyes by fitting you with a narrow, stylish shoe. In some stores it is impossible to find one pair of shoes that should be bought for useful wear. You should not try to buy useful shoes in stores which sell only dress shoes.

Here are some good rules to observe in fitting shoes.

1. Because you are growing you should be sure that shoes are slightly large when purchased.
2. Buy a shoe long enough that you can slide your foot forward in it, and still have space enough to put your forefinger behind your heel inside the shoe, when the shoe is unlaced.
3. Buy a shoe wide enough that the next larger width is defi-

nitely loose. You should be able to spread your toes inside a well-fitted shoe. Most people need shoes of widths from B to EE.

4. Make all tests of fit standing with your full weight on your feet. Put on both shoes, and be sure that your larger foot is fitted.

5. Be sure that the joint of the large toe comes at the widest part of the shoe.

6. Be sure that when the shoe is laced or fastened the shoe does not rub up and down on your heel as you walk.

Even when you have a properly fitted shoe, you may have foot trouble. Stockings or socks should fit with about half an inch of extra length. Shoes should never be worn without stockings, for perspiration soils the leather permanently. Soiled leather gives off bad odors and decays rapidly. When it decays it becomes roughened.

What care can you give your feet? You should never let your feet remain wet. It is better not to let them get wet. In winter the time-tested overshoe properly fitted over a good shoe is the best protection. Boys should not wear heavy outdoor rubber pacs or ski boots indoors all day, for they make the feet perspire.

Gymnasium shoes should not be worn everyday. A lace-to-the-toe gym shoe is better than the kind that has a toecap. The seam of the canvas-shoe toecap usually is located so that it pinches the foot.

Girls should not change from high to low or low to high heels. The tendons in the back of the leg are not elastic, and some time is required for the muscles to make the change in length necessary to adjust to different heels. You will have aches in your legs and back if you change heel heights.

EXPERIMENT: DO MY SHOES FIT?

What to use: Paper, pencil, scissors.

What to do: Remove one shoe. Stand on a piece of paper. Have a classmate draw a line around your foot, keeping the pencil straight up and down. Be sure that your weight is on your foot.

Place the shoe on your desk. Slip into it a piece of paper larger than the shoe. Press the paper with your fingers into the seams around the insole of the shoe. Remove the paper and cut it out along the impression of the insole. Compare the two. The shoe pattern should be slightly larger than your foot pattern, and the same shape.

What was observed: Make a table of results for the entire class. Classify shoes according to these headings: Too small; Too large; Wrong shape; Proper fit.

What was learned: How can you determine if a shoe fits?

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

About —1— per cent of people have foot trouble. Much foot trouble results from poorly selected

—2—. Corns and calluses result from —3— or —4— of the shoe against the foot. Shoes which are too —5— may cause toes to slip out of place. Decorative shoes should be used for —6— wear. To keep the feet warm and dry in winter properly fitted —7— are best. Perspiration is favorable to growth of fungus causing —8—.

5. How can we select suitable clothing?

Your selection of clothing is determined by a number of things. The amount of money you have to spend is one of them.

Let us consider the needs of buying clothing for a boy or girl from a family with an average income. Your clothes are probably limited in number to what you actually need, and perhaps they must be worn out before new ones are bought. They should be in good taste and capable of giving good service.

How should you plan your clothes? The first problem in planning a wardrobe is to decide what clothes are most needed. Do you have greater need for dress-up clothes, school clothes, work clothes, or play clothes? Do you need a complete outfit of each? Do you swim? The problem is to decide what you need, not what you want.

Clothing should be bought to make a complete outfit. A girl with two inexpensive skirts, a dressy blouse, and two sweaters, chosen to go well together, may look better dressed than another girl with three times as many clothes which she bought because they looked good in shop windows, but with no regard for need. Shoes should be of the best quality of any part of the outfit.

A boy needs sturdy clothes that can stand washing for school and play. The dress-up clothing need not be too expensive, for it will be outgrown soon anyway. It may be a waste of money to buy a tailored, virgin-wool suit for a boy, but such a suit would be a good buy for a man.

What is good taste? Psychologists have not been able to define good taste in exact terms. It consists of following the opinions of a large number of people who have had experience and knowledge in making choices. Certain color combinations are pleasant, while others are unpleasant. Certain lines and proportions are attractive, while others are not. This seems to be a matter of how the muscles and nerves of the eye work, and not something brought about by training. The lines and proportions of a healthy human body have always been accepted as attractive.

Styles which are attractive tend to display the body in its true proportions, without concealing or emphasizing any part unduly. Too-short skirts are not in good taste because they display any weaknesses of the legs. While slacks for girls may be use-

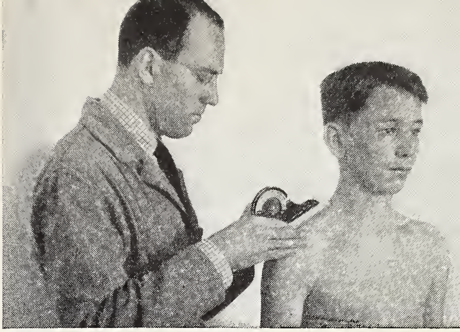
ful, it is doubtful that they will be accepted as attractive for dress wear. Because boys have narrower hips and longer legs, they can wear slacks without losing the proper proportion between upper and lower parts of the body.

These examples merely show that good taste is more than a whim. Good taste and style often are entirely different. Colors that are in good taste are not so bright that they hold the eye like an advertising sign. Yet they are bright enough to be interesting.

What is a fad? A fad is usually an extreme style—one which is not based upon sound sense. For example, the fad of wearing skirts or trousers so long that the wearers trip over them violates a first rule of safety. Wearing the bottom of the shirt outside the trousers makes it more likely to be caught on projections, and spoils the natural lines of the body. Summer sports shirts may be worn outside for the sake of coolness, but such shirts should be short. Rolling the long sleeves of wool sweaters above the elbow is another fad children have tried. As soon as such fads are given up, they appear as stupid as they really are.

Fads are frequently started by the show-off type of person who is not able to succeed through real accomplishment.

Many of you, because you have not had much experience in forming judgments, will want to try out fads. If you do, select fads which do not cost much, for articles selected as fads will be discarded long before they are worn out.

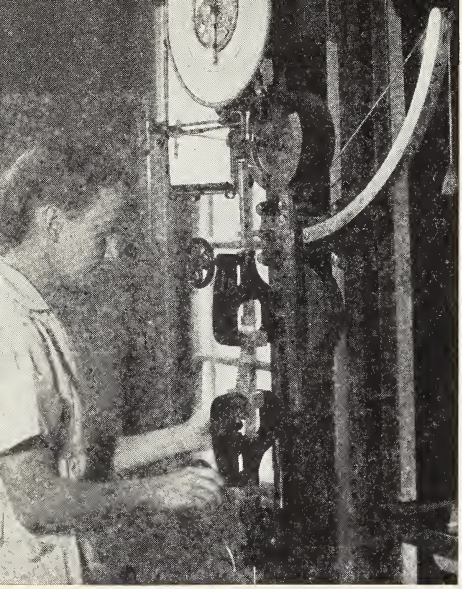


U. S. Bureau of Home Economics

To insure fit of clothing, thousands of children have been measured. The measurement is made of the angle of slope of the boy's shoulder. The device gives a reading in degrees.

Are clothes made in standard sizes? The Bureau of Home Economics of the U. S. Department of Agriculture is making an effort to develop a standard set of clothing sizes, so arranged that any normal person can measure himself and find in ready-to-wear clothing a size that will fit.

This situation does not exist today. A size-14 dress made by one manufacturer may be not only of different size but of different proportions from one marked the same size made by another manufacturer. A shirt for a boy marked size 14 refers to the circumference of the collar, but it may be anywhere from 13 to 14½ inches by actual measurement. Sizes of cheap garments are likely to be small. Unfortunately for clothing buyers, at least a third of the people in any group are quite different in size and



The most important information one can know about cloth is its breaking strength. This machine pulls a piece of cloth until it breaks. The amount of pull shows on the dial.

body proportions from the average. Only people of medium build, fairly near average size, are really fitted by ready-made clothes. Some kinds of clothes are made in tall and short sizes, but not all. Men's shirts have collars and sleeves of different size combinations. Slacks and trousers usually are made without the cuff completed, so that length may be changed.

In buying some garments there is so little chance of buying right sizes that many people prefer to make their own clothing. Every girl should learn to sew well, in order to be able to make clothing fit properly.

Stockings, underwear, and pajamas last longer if bought to fit with a comfortable looseness.

How is strength of clothing measured? Any garment that is worth buying at all should be durable. Even a party dress should last long enough that it will not pull out at the seams in the few times it is worn. A good party dress may provide material for future use in a blouse or other garment in the hands of one skillful in sewing.

The best way of judging strength of cloth is by measuring its breaking strength. A strip of the cloth is fastened between two sets of jaws. One set is attached to a spring balance with an indicating needle which shows how much pull is exerted upon the cloth. A screw is turned to pull the jaws apart until the cloth breaks. Then the reading on a dial indicates the breaking strength of the cloth in pounds. Strips for testing should be cut both lengthwise and crosswise from the cloth sample, in order to be sure that the two sets of threads are of nearly equal strength.

Every buyer of cloth is entitled to know, without having to ask, what the breaking strength of the cloth is, and to know how many threads are woven into it per inch.

Does cloth fade? The development of the dye industry has made it fairly probable that cloth made into most garments will not fade noticeably before the garment wears out. Fading is most likely to occur in cheap

felt hats, suits made of re-used wool, and in dress materials of especially brilliant colors. Cloth fades much more rapidly in summer than in the winter. Use of strong soaps and bleaches in the laundry will fade most cloth.

Does cloth shrink? Some cloth is guaranteed against shrinkage more than 1 per cent of its length. Other cloth is not treated in any way, and may shrink as much as 10 per cent of its length. Wool socks and wool underwear, if improperly washed, may shrink every time they are laundered, until they become useless. Most wool suits shrink when pressed with a damp cloth. Selection of clothes guaranteed against shrinkage is desirable.

How should you examine clothing you intend to buy? The general inability of people to observe accurately extends to their clothing also. When buying clothes it is easy to look at a buttonhole to see if it is placed well back from the edge of the cloth, and to look at the underside of fancy buttons to see if they can be sewed on if they come off. Little skill is required to count the number of threads that have been used in sewing on a button. If a lining is set into place with raw edges showing and with stitching carelessly missing the edge of the cloth, you can suspect that the quality of the garment is low. Clothes should have seams deep enough to hold the thread securely, and to allow for some change in size in case of shrinkage. Too many decorations are usually the sign of a poorly made garment. Anyone who has had some practice in sewing can detect poor workmanship.

Why should you use clothing correctly? When you have made a good buy, you still can ruin your clothes or the impression you make by their incorrect use. Silk or nylon stockings are not made to be worn for active work or for games or hiking. Cotton stockings, of the kind knit in bright colors, are more durable and more attractive for sports. White dress shirts are not intended to withstand the strains of wrestling. Dress shoes are not intended for school or for games, and should not be worn for such purposes. Shorts and slacks are not proper for street wear. Boys are too likely to try to avoid dressing properly. They should know that a necktie is part of every well-dressed boy's outfit on certain occasions.

For a picnic in the woods, a pair of slacks is more suitable for a girl than a dress. There protection is more important than good appearance. Shorts are perhaps more attractive than slacks, but they should be worn only informally at home or for sports. They are not suitable for downtown wear.

Buying your clothing is your own problem. Your needs are not those of every other person of your age. You should be an individual and select clothing in good taste to fit your own requirements. You should pay only

enough attention to style to be dressed like the average person in the crowd in which you move.

DEMONSTRATION: HOW IS THE BREAKING STRENGTH OF CLOTH MEASURED?

What to use: Two C-clamps, 24-pound spring balance, small blocks of wood, board, cloth samples.

What to do: Clamp a strip of the cloth in place as shown in the diagram. Strips 1 inch wide should be carefully cut or torn from the samples. Pull on the balance until the sample breaks, noting carefully the measurement on the balance at the instant the cloth breaks. Samples of new cloth may be too strong to tear by this test.

What was observed: What is the breaking strength of the samples tested? Do samples differ in strength?

What was learned: What useful idea have you gained for knowing the value of cloth in clothing you buy?

Things to think about

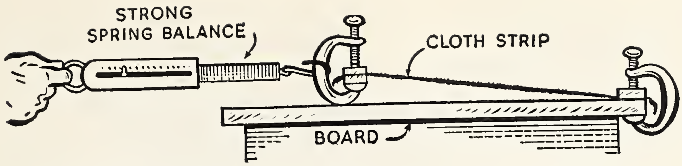
Copy the following sentences in your notebook. Select the correct conclusion.

1. Color of clothing is not changed by (*a*) laundering (*b*) sunlight (*c*) wear.
2. People who study man's behavior are (*a*) bacteriologists (*b*) zoologists (*c*) psychologists.
3. A silly, impractical style that soon passes is a (*a*) whim (*b*) sales promotion (*c*) fad.
4. Standard sizes are best determined by (*a*) measuring many people (*b*) using uniform marking (*c*) having manufacturers decide on them.
5. The breaking test of cloth shows its (*a*) attractiveness (*b*) strength (*c*) durability.
6. Properly prepared cloth shrinks not more than (*a*) 1% (*b*) 5% (*c*) 10%.
7. Girls wear slightly less clothing indoors than do boys because they (*a*) have become accustomed to them (*b*) use less energy (*c*) wear warmer clothes.
8. On a hike one should wear (*a*) silk hose (*b*) cotton socks (*c*) gym shoes.
9. One should buy clothing to (*a*) meet his own needs (*b*) keep up with fads (*c*) have clothes for all possible needs.

6. How is clothing cleaned?

Nothing else about our clothing can make as bad an impression as our failure to keep it clean and neat. Being dirty or careless can never be excused as a fad among people of taste and education. Carelessness shows a serious lack of understanding of how to get along with people, as well as a lack of understanding of how to protect one's own health and self-respect.

How do we wash clothing? You know that oil and water do not mix readily. Yet most of the materials that are difficult to wash off our clothing are mixed with oil from our skins. Since soap readily dissolves in the water, it is used to form a film



This is the apparatus needed for the demonstration on page 302.

around the droplets of oil. Soapy water separates the oil into fine drops. Such a mixture of soap, fine drops of oil, and water is called an emulsion [ė·mŭl′shŭn]. The bubbles of soapsuds are also used to loosen the dirt. The movement of soap through the spaces between the fibers actually pushes the dirt from the garment.

Ordinarily soap is made by boiling together a fat with lye. The fat most commonly used is beef tallow, but coconut oil, waste lard, cottonseed oil, and many other fats may be substituted. Most soap factories are connected with packing plants, and use the waste fats from meat packing for soap-making.

In the laundry, soap may best be used in connection with a water softener. Soap should be rinsed from the clothing completely.

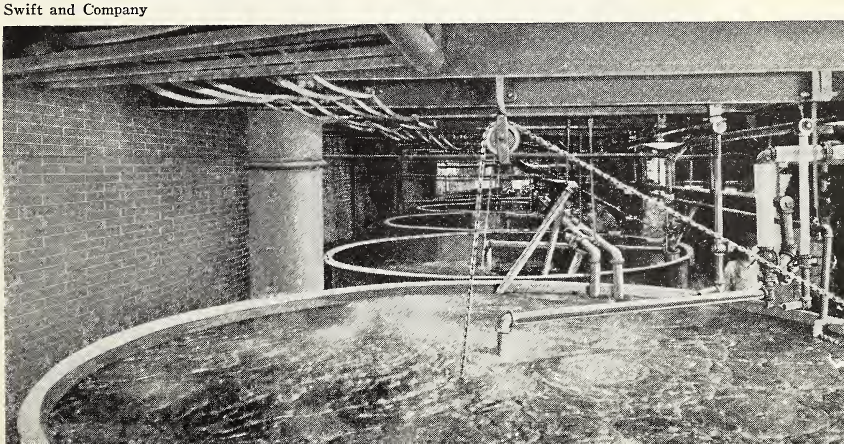
The temperature of the water for washing cotton should be kept as high as practical, for hot water not only washes clothes cleaner, but kills bacteria.

For woolens, silk, and most synthetic fabrics, it is best to use a mild soap and warm water. The action of soap alone will kill some germs without use of heat.

Colored clothes are hung out to dry without treatment other than rinsing. White clothes are rinsed in water containing bluing. Bluing covers up the yellowish color that comes from wash-

Soap—the most necessary chemical next to water for keeping clean—is made in these huge kettles by boiling together fats and lye. The fats come, to a large extent, from meat-packing plants.

Swift and Company



ing white clothing in water that leaves soap scum.

Commercial laundries may use a bleach on white clothing. The chemical usually employed is chloride [klō′rīd] of lime or sodium hypochlorite. These chemicals give off chlorine, which destroys the coloring material. It is washed off in a chemical solution. Unless it is completely removed from the cloth, it may cause the material to weaken and wear out. Chloride of lime is also irritating to the skin.

Underclothing should be washed frequently, not only to avoid odor, but to increase the life of the clothing. Rough treatment of clothes in washing wears them out, however. One of the reasons for wearing underclothing is to protect our heavier, outer clothes from contact with our skins. For this reason, underclothing should be our most easily washed garments.

Perspiration often contains chemicals which destroy the strength of cloth. Any clothing in which you prespire should be washed immediately.

Ironing not only improves the appearance and fit of clothing, but also kills many types of germs.

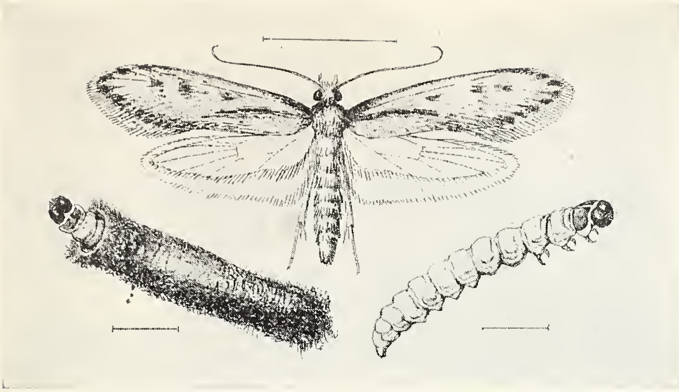
How do detergents work? A new class of cleaners developed in recent years are the detergents. They work in water solutions by dissolving fats. They are sold under trade-marked names, which have now become quite familiar. These cleaners are better than soap for washing dishes and for laundering slightly soiled rayons, nylons, silk, and wool. They are not very effective for heavily soiled cotton clothes.

A detergent works because it lessens the ability of the water molecules to stick together. In a solution it actually makes water wetter. The water becomes more able to penetrate the fabric and particles of dirt, thus loosening the dirt.

Detergents do not form scum in hard water. Dishes washed in detergents will drain clean if rinsed in hot water that is not too full of mineral hardness.

How are clothes dry-cleaned? Dry cleaning is greatly different from washing clothes. To dry-clean a garment, it is washed in one of the chemicals which will dissolve oils and grease. One of the most common of these is naphtha [năf′thȧ], a kind of gasoline. Another is carbon tetrachloride [tĕt′rȧ·klō′rīd]. Naphtha is cheap but explosive, and cannot under any conditions safely be used at home. Common gasoline is much more explosive still—in fact, it may be exploded by invisibly small sparks caused by rubbing silk and wool together. Most common gasoline contains lead, a metal which is a deadly poison in contact with the skin. Do not try to dry-clean at home.

Carbon tetrachloride is fairly safe. Although it is poisonous, the fumes can be removed from a well-ventilated room. Its cost is too great to make its home use economical. Commercial dry



This is the type of clothes moth that makes cases. The harm is done by the larva. The adult rests with its wings folded and not spread as in the picture.

cleaners mix carbon tetrachloride and naphtha, and have special safeguards to avoid sparks. They filter the cleaning fluid and use it over and over.

Dry cleaners have soaps which they can add to cleaning naphtha to make it more effective. The odor is removed from clothing by a low-pressure blower.

It is best not to buy much clothing that needs dry cleaning. Washing is cheaper, safer, and more satisfactory.

What is a spot remover? Spot removers of the explosive type are usually made of benzine [bĕn′zēn], a type of gasoline product. The nonexplosive spot removers are made of carbon tetrachloride. Neither will remove spots completely but if used properly will blend them into the cloth until they are not noticeable on dark clothing.

To use a grease spot remover, the stained material is laid wrong side up on a pad of cloth. The spot remover is applied to the back of the cloth with a sponge or clean cloth. As it soaks through the soiled cloth into the pad of cloth, it dissolves and carries grease with it. Fumes of both benzine and carbon tetrachloride are fairly poisonous.

What is a stain remover? Some stains are easily removed. Spots of oil may be removed by dissolving them in a dry-cleaning fluid. Some oil can be removed by putting blotters above and below the stain, and pressing the upper blotter with a hot iron. Oil can often be absorbed by putting chalk or corn meal on it.

A common bleaching solution is Javelle water. It is made by stirring two tablespoonfuls of chloride of lime into a quart of water, then adding four tablespoonfuls of washing soda. The solids which settle out are not used, but the clear liquid is poured off for use. It is a bleach, and will remove not only some

stains but color as well. Mildew stains are especially well removed by use of this solution.

Alcohol will dissolve iodine stains completely and will remove many grass stains. Cheap rubbing alcohol is satisfactory for this use.

Lemonade and other acid stains can be removed by use of washing ammonia, if it is applied soon enough. Iron rust can be dissolved in a weak solution of hydrochloric acid, which then is removed from the cloth, after it has been rinsed, by use of ammonia.

How do we keep moths out of our clothing? Many of the products advertised to kill moths are of little value. Cedar chests and moth balls are only slightly effective. The best safeguard against moths is to keep all wool and fur clothing clean, and stored in tight boxes.

To kill moths in wool clothing, have the clothing dry-cleaned or wash it in the usual way. Spray the inside of closets, chests, and drawers; the upholstered furniture in the room; the edges of wool carpets; and other breeding places of moths with DDT or some other effective moth killer. A kerosene solution is best, if used according to directions. DDT in oil vapor is unsafe to breathe. DDT may be sprayed directly on clothing which does not come into contact with the skin.

DEMONSTRATION:
HOW IS GOOD SOAP MADE?

What to use: Nine cups of used kitchen fats, one pound of borax, one pound of commercial lye, eleven cups of cold water, or proportional parts; porcelain or enamel container large enough to hold recipe; wooden mixing spoon or paddle, vinegar for safety purposes. (*Warning*: Lye causes serious burns. Keep your hands out of it. Do not breathe its dust. If you get lye on your fingers, wash them quickly with vinegar.)

What to do: Clear the melted fat by stirring it into hot water. Let it cool and pour out the water. When the fat is solid, carefully add the lye and borax by pouring the chemicals on top of the fat and stirring them into the fat. After the chemicals and fat are thoroughly mixed gradually add the cold water. Mix for about 20 minutes or until a thin batter results.

Pour the soap into flat pans so that it may be cut into bars when solid. Let it remain in the pans overnight before putting your hands in contact with the soap. Chemical action continues even after mixing is complete. The next day after making the soap, cut it into convenient bars. It may then be handled as any soap may. If any liquid remains, discard it. It is a strong lye solution. (*Danger.*)

This recipe makes about 20 standard bars of excellent hard-water soap. It is suitable for washing dishes and for laundry. Perfume may be added to the water if desired.

What was observed: What are the essential materials for making soap? What dangers must be avoided? Is soap-making easy?

What was learned: Is making soap a chemical change? Why do you think

so? Would it be worth your while to make soap at home from used fats? Compare the cost of homemade and commercial soaps.

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

Soap and fat form an —1— in water. Soap is made from —2— and —3—. In dry cleaning, oil is —4— in naphtha. Alcohol will dissolve —5— and —6— stains. Moths in clothes may be killed by use of —7—. —8— type spot removers are explosive, but those made of —9— are not.

A review of the chapter

Our clothing is primarily useful to keep us warm, to protect our bodies from injury and from bites of insects, and to protect our bodies from the sun. It satisfies many other needs, such as the need for making a good appearance, the need for expressing one's own feelings, and the need for helping to fit into our social group. Clothing for wear out of doors should be selected for its ability to protect us. The most economical warm clothing consists of tightly woven cotton over a wool or sheepskin garment.

The fibers used for making clothing are either taken from natural plant and animal sources or are manufactured by chemical processes from a number of common raw materials, such as milk, coal, air, and wood. These man-made fibers are synthetic.

We should buy clothing first of all because it meets some real need of our own. Clothing should be in good taste; be selected for economy, good fit, and durability; and be of reasonably new style. Health is affected by the correctness of design, fit, and durability of shoes.

Clothing is best kept clean by use of soap and water. Soap and oil make an emulsion in water. Oils and fats on cloth may be dissolved in naphtha and carbon tetrachloride. New types of cleaning chemicals, called detergents, and new types of moth-proofing materials aid in caring for clothing.

Word list for study

Be sure that you can pronounce, spell, define, and use in a sentence every word in this list. Each of these words has been defined or explained and used in this chapter.

synthetic	fiber	lye
boll	rayon	casein
infection	insulation	evaporation
ultraviolet	callus	bunion
perspiration	fad	emulsion
detergent	naphtha	carbon tetrachloride
bleach	borax	chemical

An exercise in thinking

Below are two groups of sentences. The first group contains principles, which are large general ideas. Each sentence in the second group contains an idea related in some way to one of the principles in the first group. Write the numbers from 1 to 25 on a piece of paper or in your notebook. Find the principle which best explains the idea in the second list. Then after the number on your paper write the letter before the related principle.

List of principles

A. Loss of heat is prevented by use of insulating materials.

B. Evaporation of water requires heat.

C. Water mixes with oil only in an emulsion.

D. A solution is a completely uniform mixture of one substance in another.

E. The materials forming one or more substances may be changed chemically to produce one or more different substances.

F. Good absorbers of heat are good radiators but poor reflectors.

G. Good taste in clothing is based upon custom, habits of operation of the eye, and association of ideas.

H. Continued pressure may change the shape of the body, or interfere with its operation.

List of related ideas

1. A white straw hat is good to wear in the sunshine.
2. Because wool cloth holds air, it is desirable for winter wear.
3. Clothes which follow the natural lines of the body usually look attractive.
4. We should wear rubbers to keep our feet dry.
5. Rayon is made from wood pulp.
6. Soap removes dirt left on clothing by the skin.
7. White clothes are cool on summer days.
8. Carbon tetrachloride is used for dry cleaning.
9. We should wear clothing in summer to prevent too rapid evaporation of perspiration.
10. Red and green used together in clothing must be dull to be pleasant to the eye.
11. We can wash most oil spots from clothing.
12. Artificial wool is made from milk chemicals.
13. We are kept warm by a layer of heated air inside our clothing.
14. Iodine can be removed from cloth by using alcohol.
15. A black coat gives off heat faster than a white coat on dull, cold days.
16. We are likely to catch cold if our clothes get wet.
17. Nylon is sometimes made from corncobs.
18. Underwear should allow some perspiration to evaporate from the skin to keep us comfortable.
19. Fur is one of the warmest of all clothing materials.
20. Poorly fitted shoes cause flat feet.
21. Dirt from the skin is harder to remove from clothing than is some other dirt.
22. Elastic in underclothing may interfere with circulation.

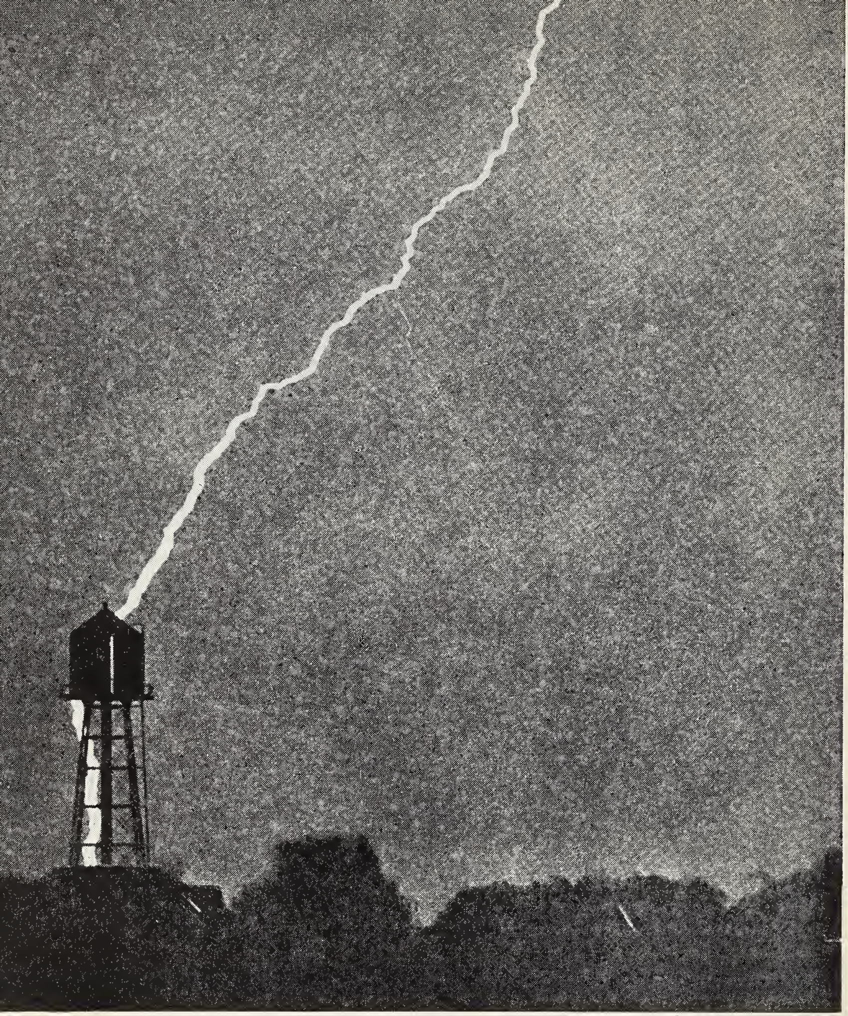
23. Dry cleaning removes oil better than it does rust.
24. No style can last if it is based upon emphasizing one part of the body too much.
25. Corns and calluses result from shoes that are fitted badly.

Some things to explain

1. What did you learn in studying buying that is of value in explaining why people select the clothes they do?
2. Is killing of birds for use of feathers in hats a desirable practice? Why is the law not always enforced?
3. What will the cotton and wool producers do for a living if all fabrics are made synthetically? Will such a change affect your community?
4. Are the pupils who start fads in your classes inclined to be show-offs or "spoiled" in any way?
5. How much money are you entitled to as your share of the family income for clothing?
6. What permanent injury may result from fads in shoe style?

Some good books to read

Bennett, J., *How To Be Attractive*
Burnham, H. A. and others, *Boys Will Be Men, Revised*
Consalus, F. H., *Distinctive Clothes*
Daly, S., *Pretty Please!*
Dana, M., *Behind the Label*
Denny, G. G., *Fabrics*
Potter, M. D., *Fiber To Fabric*
Ryan, M. G., *Your Clothes and Personality*



U. S. Weather Bureau

UNIT FIVE

THE ATMOSPHERE AND OUR CLIMATE

Fred carefully put a cardboard box on the table. From another box he took a 15-inch length of pipe. He laid the piece of pipe on a stand over a heater before starting to explain his experiment. When he finally was ready, he said, "I am going to demonstrate the effect of heating and cooling on air currents. I have one piece of pipe over the heater. In this box I have a similar piece of pipe packed in dry ice with newspaper wrapped around it. I will now set up the cold pipe on this stand."

He handled the cold pipe with a pair of pliers, and clamped it on a stand. As soon as this was done, he picked up a sliver which he held in the flame. Instead of bursting into flame, it merely glowed and smoked.

Fred said, "The smoke from this piece of punk will show you which way the air moves through the pipe. Observe closely."

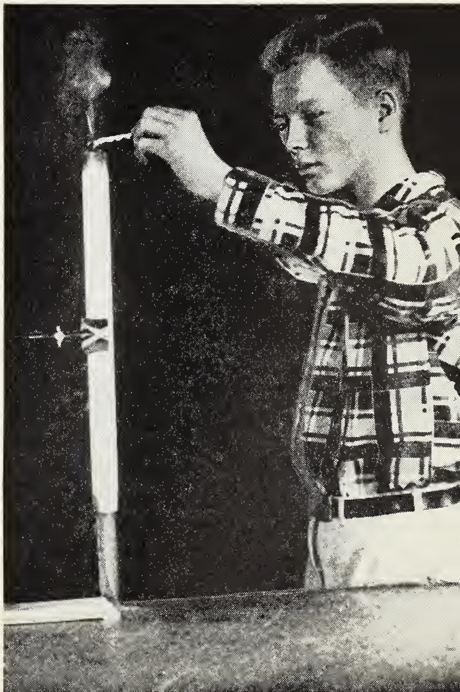
He first held the smoking punk below the pipe. The smoke was swept downward before it drifted away. Then he held the punk above the pipe in different positions. The smoke was drawn down through the pipe and came out at the lower end.

By the time he had completed this part of the experiment the other pipe was quite hot. He put it in place on the stand instead of the cold pipe.

As he picked up the piece of punk, he continued, "You will observe that the cold pipe condensed considerable water vapor from the air. It is moist on the outside. This pipe is dry. Now watch the smoke."

He held the punk at the top and bottom of the hot pipe. As the class expected, the smoke was forced to rise when the punk was held above the pipe. When the punk was held beneath the pipe, the smoke was drawn through the pipe and came out of the top.

Fred had to wait till the hot pipe cooled so that he could put it away.



CHAPTER

9

Our Earth's Atmosphere

We know that we must live in air in order to survive. We know that most of our everyday activities depend upon air to some extent. Air is related to life and most life activities.

All the air of the earth taken together makes up its atmosphere. The atmosphere may be considered a great transportation system which carries heat and water vapor from one place to another. It also carries dust, spores, and other small solid materials. Without circulation of the atmosphere hot regions would be much hotter and cold regions much colder than they now are.

The atmosphere also acts as a great blanket which absorbs and holds energy from the sun. There are several kinds of radiant energy which strike the earth. Some of them are so destructive to life that few organisms could survive if these rays were not absorbed in the upper air. More than a hundred miles above the earth the daytime temperature of the air is very high, perhaps a thousand degrees. There the sun's rays first strike air so thin that it is like a vacuum in a common electric lamp. The denser, lower air also absorbs heat and light, and holds this heat so that we are kept cooler in the daytime and warmer at night than would be possible without the atmosphere.

Some activities to do

1. Test the force of air pressure. Obtain a flask, a balloon, and a stand and burner. Put about an inch of water in the flask, attach it firmly to the stand, and bring the water to a boil. After the water has boiled two or three minutes, slip the balloon over the neck of the flask. (Careful—use a towel.) Continue the heating until the steam inflates the balloon. Then let it cool. Observe what happens. Heat the flask again. By squeezing on the balloon with a towel over the hand, the rate of boiling can be reduced. Explain.

2. Obtain as many kinds of instruments for measuring humidity as you can, and demonstrate them. Explain how they work.

U. S. Weather Bureau

This is the weather observatory on the top of Mt. Washington in New Hampshire.

3. Make models of several weather instruments. Rain gauges, anemometers, wet-and-dry bulb thermometers are not too difficult to prepare.

4. In an illustrated encyclopedia or dictionary look up sundials. Find one which is not too complex to make, and make a working model.

5. Observe at a certain time of day where the shadow of a bar of a window falls on the floor. Mark its location. At other times of year similarly mark the location of the shadow at the same time of day. Be sure to check the timepiece for accuracy.

6. Obtain a bright tin can, some ice, and some salt. Mix the ice and salt and observe the can to see if water condenses on it and if frost forms. If you have a thermometer take the temperature of the mixture when each forms. Where does the water come from?

7. Set open dishes of equal amounts of water in various places to test their rates of evaporation. Such places as a closed storeroom, a shelf above a radiator, a place beside a ventilator, and on an outdoor window-sill are suggested. If you find differences, explain the causes.

Some subjects for reports

1. Rocket flights into the stratosphere

2. The stratosphere balloon flights and their results

3. The effects of volcanic explosions on temperature

4. The best and worst places for developing wind power

5. Rainfall records for different places in the world

6. Evaporation-coolers commonly used in deserts and the dry Western states

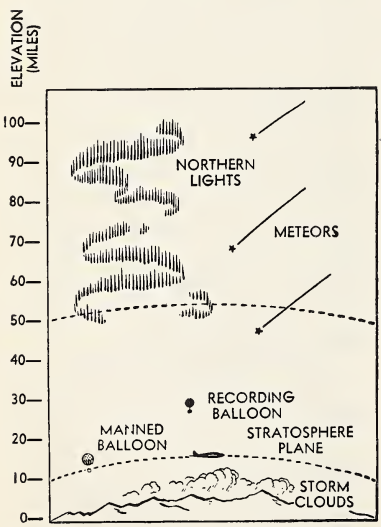
7. How American Indians spent the winter

8. The long night of the Arctic

1. *What is the atmosphere?*

All the air surrounding the earth is its atmosphere. We do not know just how important the upper atmosphere is to our welfare. In fact, we are not even positive where the upper limits of the atmosphere may be. We are sending rockets loaded with instruments into the upper air to measure conditions there, and we have several kinds of indirect evidence about its condition.

What is the lower air like? You already know that the air is a mixture of gases, most of which are found in about the same proportions all over the earth. Approximately one-fifth of the air is oxygen. About four-fifths is nitrogen. There is not much carbon dioxide anywhere, but because it is so much heavier than the other parts of the atmosphere, it is somewhat more abundant nearer the earth than in the upper air. About three parts of air in ten thousand are carbon dioxide. Other gases make up about 1 per cent of the air. These are the inactive gases which do not change chemically in ordinary reactions.



Although man has explored only the lower part of the atmosphere, there is much evidence that it extends far above the earth.

All the figures given for the make-up of the air describes dry air. But in the outdoors there is never any such thing as really dry air. Air may contain as much as 4 per cent water vapor, or very little. When air does contain much water vapor, many things may absorb water from the air and become damp. Girls may have noticed that their naturally straight hair loses its curl on very humid days, while naturally curly hair may become more curly. Paper becomes limp on humid days. On dry days the air absorbs water from almost all objects.

Air is constantly in motion. There are several kinds of air motion. There are local movements of air wherever things have differences in temperature. Even around a lamp there are

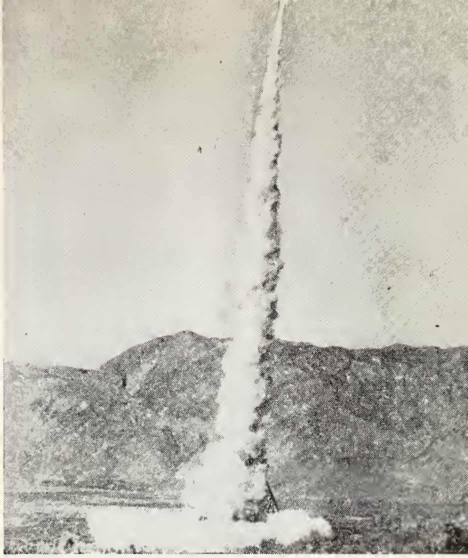
updrafts of air, and on the shady sides of buildings there are downdrafts. Hills, forests, lakes, rivers, mountains, and differences in the color of the soil cause air to rise or fall, depending upon the local temperature differences.

The second type of movement includes larger masses of air. These large air masses break away from their starting locality, and move a considerable distance, sometimes halfway around the world, before they break up. The air mass keeps its original condition for some time. If a mass of cold air sweeps southward from the North Pole, it will remain dry and cool until it has passed over warmer, more humid regions. Warm air masses from the ocean and the Gulf of Mexico usually lose moisture as they become cooler, but still are warmer and more humid than the average condition of the regions over which they pass.

There are large drifts of air which make up the world wind system. And there are great shifts of these wind belts with the seasons.

The lower atmosphere is the region of storms, or violent changes in the condition of the weather. It is a layer of air about four miles deep at the poles, and not more than ten miles deep at the equator. An average depth is six or seven miles.

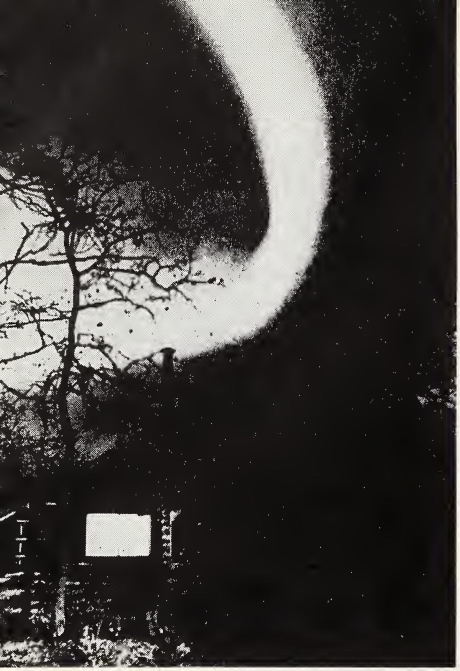
What is the stratosphere? The stratosphere is the layer of air just above the layer in which we live. It differs in many ways from the lower air. There are no violent storms there. The winds of the stratosphere may be rapid, but they are steady. There are no ordinary clouds in the stratosphere. Water vapor sometimes freezes and forms ice crystals in the lower stratosphere, making a thin, hazy looking cloud. These clouds never produce rain or snow.



Science Service

This liquid-fuel rocket is a type frequently used to carry instruments into the upper atmosphere for studying its condition.

Air pressure in the stratosphere ranges from less than one-tenth of that at sea level to almost nothing. Because this upper air is thin it offers less resistance to bodies moving through it than does the lower air. Airplanes and rockets move faster in the stratosphere than near the earth. The air of the stratosphere offers enough resistance to motion to cause meteors to burn up when



Robinson Studio

The Northern Lights are much brighter and clearer near the North Pole than they are in the United States. This display was photographed in Alaska.

they strike it. The best evidence we have as to the density of the upper air is its ability to resist the movement of meteors, producing friction which heats them. The upper air must contain oxygen or the meteors would not burn.

Northern lights may seem mysterious. You are familiar with neon lamps. A neon lamp looks empty, and in fact is almost empty except for very little neon gas. When a high-voltage electric current is shot through the neon gas, it glows with a deep-orange light. Only neon produces this particular kind of orange light. Neon is one of the rarer gases of the atmosphere.

The northern and southern lights are caused by a similar discharge of electricity through thin gases in the upper atmosphere. The electricity seems to be provided by either energy particles or magnetic radiations given off by the sun, particularly when there are sunspots. The colors of northern lights indicate that there is more helium and hydrogen, the two lightest gases, in the upper air than in the lower air.

Men who have gone into the stratosphere in balloons have had trouble maintaining the right temperature. The room which is carried aloft by the balloon is a sealed aluminum ball. Some experimenters have painted the metal ball black. When this black ball rose above the protection of the upper air, it absorbed so much energy from the sun that it became unbearably hot. Other experimenters tried painting the aluminum ball with aluminum paint. It reflected so much heat that the men were nearly frozen, for except for one warm layer of air, the stratosphere is very cold, 40 to 80 degrees below zero. More recent experimenters have put just enough black paint on the aluminum balls to provide about the right amount of heat.

There are other layers of the air. Some are made up of particles of air and other matter carrying electrical charges. These layers reflect ordinary radio waves.

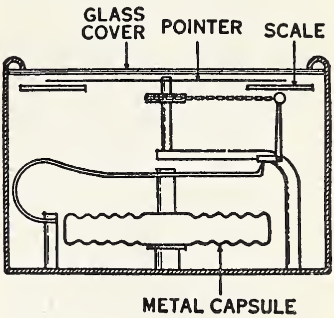
It may be that our weather is really made in the upper atmosphere, where the electrical condition of the air affects the absorption of the sun's heat by the lower air. This is not known, but is a problem now being investigated.

If we could discover some way to predict the weather for a month or a year in advance it would be very useful. Supplies of fuel, pipes for irrigation, heaters to protect against freezing, and plans for travel could be provided for certain kinds of weather. If you know in advance that you are going to have a cool summer, you might save vacation travel money by staying at home.

Things to think about

Copy the following sentences in your notebook. Select the correct ending for each sentence.

1. The average depth of the lower atmosphere in miles is (*a*) 4 (*b*) 7 (*c*) 10 (*d*) 80.
2. The gas which makes up about four-fifths of the atmosphere is (*a*) oxygen (*b*) nitrogen (*c*) carbon dioxide.
3. When men go into the stratosphere in balloons they must carry a supply of (*a*) oxygen (*b*) nitrogen (*c*) carbon dioxide.
4. At ordinary temperatures the water vapor in the air is not likely to be more than (*a*) 1 per cent (*b*) 4 per cent (*c*) 8 per cent (*d*) one-fifth.
5. Downdrafts are likely to occur wherever it is (*a*) humid (*b*) hot (*c*) cool (*d*) drafty.
6. Northern lights may occur in the upper stratosphere when there is a discharge of (*a*) moisture (*b*) radiation (*c*) electricity.
7. Heat absorbed by a black stratosphere balloon ball comes from the (*a*) sun (*b*) surrounding air (*c*) earth.
8. Clouds which produce storms might possibly reach a height as great as (*a*) 1 mile (*b*) 2 miles (*c*) 5 miles (*d*) 20 miles.



The aneroid barometer is the most convenient device used for measuring air pressure. The pressure upon the springy sides of the metal capsule causes it to vary in thickness. The levers show the amount of change in terms of air pressure.

2. How are atmospheric conditions measured?

The condition of the atmosphere is easily described in general terms. We can say that the Southwest is hot and dry, while the South is hot and humid. Such general statements have little value from a scientific standpoint. To know what the conditions of a given region really are, it is necessary to keep accurate

records over periods of many years. To do this it is necessary to measure the weather from day to day. The necessary averages are worked out from daily observations. The averages can be accurate only if they are taken from measurements that are accurate. To make satisfactory measurements, it is necessary to use measuring instruments. Instruments are used to measure temperature, humidity, air pressure, wind velocity, rainfall, and hours of sunshine.

How is temperature measured? The mercury thermometer is still the most accurate and reliable of instruments for measuring temperature. Although ordinary cheap thermometers are not accurate, those used by the U. S. Weather Bureau are made more carefully and are quite reliable.

The freezing point of water is the key point in describing temperature. On the thermometer it is fixed by placing the bulb in ice water. The boiling point is fixed by placing the thermometer in boiling water. The conditions under which these points are marked must be exactly standard. The air pressure must be normal when the water is boiled, and the water must be pure. Between freezing and boiling points the scale is marked in 180 equal parts. Then 32 degrees are added below the freezing point to find the zero point. There is no particular reason for the zero point being 32 degrees below freezing, except that the inventor of the scale, Fahrenheit, found he could obtain that temperature by placing the thermometer in a mixture of a salt and ice. The boiling and freezing points are called the fixed points.

Most thermometers do not have scales extending to the boiling point but are marked by comparing them with a standard thermometer. The best thermometers are those which have been marked by the United States Bureau of Standards, but they are expensive. The thermometer often used in science rooms has only 100 degrees between the freezing and boiling points. This scale is called the centigrade scale.

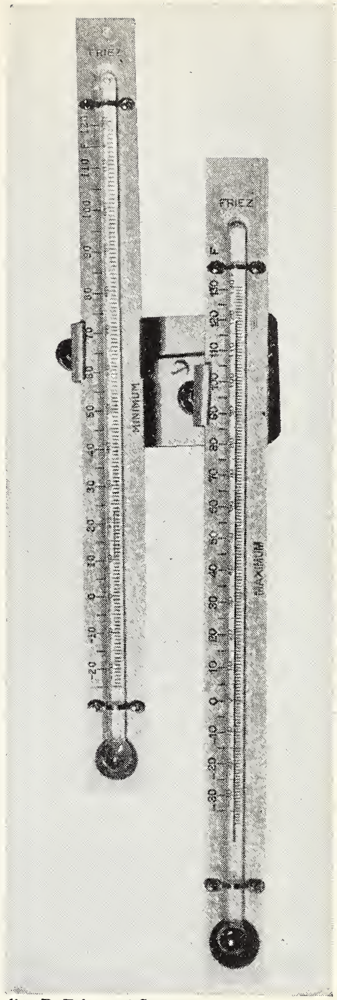
What is a recording thermometer? To make a record of the highest and lowest temperatures of each day, a thermometer with two tubes is used. In each tube is a spool-shaped piece of iron. One tube is so arranged that the metal marker is pushed along by the mercury when the temperature goes down. The other tube is arranged so that the mercury pushes the second marker when the temperature goes up. The markers remain in place when the mercury has pushed them to the lowest and highest temperatures of the day. The weather man reads the high and low temperatures from the position of the markers, and then resets the thermometer by moving the markers back against the mercury columns with a magnet. The high reading is recorded as the maximum temperature. The low

reading is the minimum temperature.

The thermometer which traces a record on a piece of paper contains a compound bar made of two metals. The bar bends with the changes in temperature, and moves an arm up and down. A pen on the end of the arm makes a mark on a piece of paper. The sheet of paper is wrapped around a cylinder and turned around by clockwork. The result of the movement of the pen and cylinder is an irregular line that shows the ups and downs of the temperature during the day. A recording thermometer is called a thermograph.

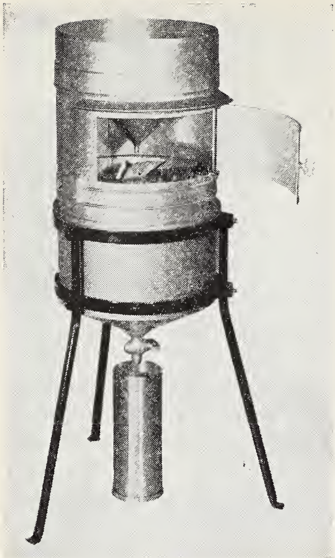
How is the barometer used? The barometer is of more importance for forecasting weather than for recording climate. The standard barometer is the mercury barometer. When this barometer is carefully made, by boiling the mercury in the tube to get rid of air bubbles in the tube, it measures air pressure accurately. To read the height of the column of mercury, there is a mirror behind the mercury in the cup in which the tube is inverted. By turning a screw, the level of the mercury is adjusted until the mercury in the cup and its image in the mirror are exactly in line with a mark on the glass tube. At the top of the tube there is a sliding metal scale which can be used to read the height of the column accurately to hundredths of an inch.

The mercury measures the pressure of the air which is just sufficient to balance the column of mercury in the tube. Air pressure is one of the important



Julien P. Friez and Sons

The maximum-minimum thermometers record the high and low temperatures of the day. The metal spool gives the minimum temperature.



Julien P. Friez and Sons

The tipping bucket rain gauge is used in the large stations of the Weather Bureau. Rain falling from the funnel into the scoop tips it so that it spills. A record is made each time the water is dumped.

factors in causing changes of weather. The recording barometer works on a different principle. It operates a marker much like that used on the recording thermometer to make a line on a piece of paper.

How is rainfall measured? Most of the small stations use the funnel type rain gauge. The rain gauge used in the large stations of the Weather Bureau looks like a milk can on legs. The rain water runs down a funnel into a scoop-shaped bucket. As the bucket fills, it tips, empties out the water, and returns to its position. A device is provided which records the amount of water emptied in terms of inches of rainfall.

How is sunshine recorded? The sunshine recorder is a thermometer-like tube placed inside a larger vacuum tube. The sun shining upon the mercury causes it to expand and close an electrical connection, which in turn causes a pen to make a broken line upon a paper on a revolving drum. The pen makes a solid line when the sun is not shining.

How is wind velocity measured? The wind gauge is made up of three or four cups placed to rotate upon arms connected to a shaft. These cups are turned by the wind. The stronger the wind, the faster the cups whirl. A magnetic arrangement makes a weak current when the cups whirl slowly, and a stronger current when the wind blows faster. The current is used to register the velocity of the wind upon a dial, to which the gauge is connected by wires.

How is humidity measured? The wet-and-dry bulb thermometer with which you are familiar is used to measure humidity. The difference in temperature indicates the humidity, by reference to tables. To speed up the evaporation from the wet bulb, the thermometer is whirled by hand or placed in a current of air from a fan.

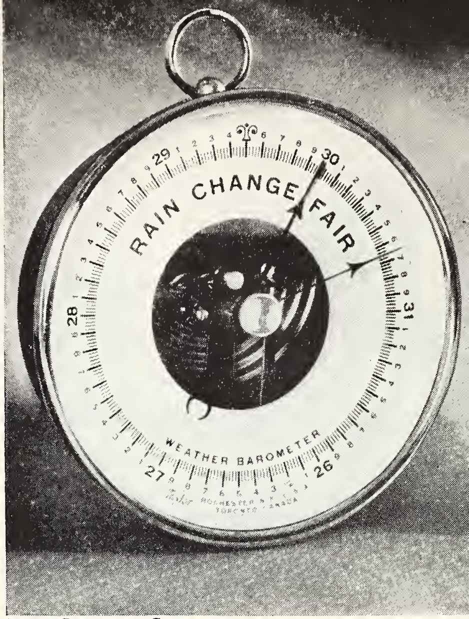
Humidity may also be measured by use of a strand, or strands, of hair, which change in length with changes in humidity.

The recording hygrometers [devices for measuring humidity] use the multiple-strand system. These devices are not very accurate.

How are averages determined? Altogether there are more than 6000 weather stations in the United States. Each of them keeps some records, but only the larger stations keep complete records. The averages are put on maps, and lines are drawn through the points on the map with equal temperatures, rainfall, and snowfall. The large maps of the Weather Bureau show many more lines than are shown on the rainfall and the temperature maps in this book. In fact, there are so many lines that some experience in reading maps is required to understand them.

The rainfall map does not necessarily show the rainfall for any one year. It indicates the average over a number of years. Almost never does one year have exactly the average rainfall. The rainfall does not vary ordinarily more than 20 per cent from the average. That is, if the rainfall average is 30 inches, it is not likely to go above 36 inches or below 24 inches in any year.

Why are records of climate important? To make the best use of the lands of the United States, it is essential to know the climate of different regions. There are some regions now under cultivation which are fitted only for pasture, because there is not enough rainfall to grow crops. The average date of killing frost in spring and autumn is important to gardeners. Windmill manufacturers must know the average velocity of the wind in order to make the windmills capable of delivering enough power. The businessman who is going to establish a new factory must know how many hours' work can be done by daylight. Spinning can be done best where the humidity is high. There is hardly an activity of man which is not affected in some way by the influence of cli-



Taylor Instrument Company

The barometer is the most convenient means of measuring air pressure. This barometer can be carried without danger of spilling or breakage. It contains no mercury, but the readings are equal to the height of a column of mercury in a barometer.

mate. The only way to know the climate is to keep records based upon the use of measuring instruments.

Things to think about

Match the following subjects and predicates. Copy the sentences in your notebook.

Subjects

1. The thermometer
2. The maximum-minimum thermometer
3. The barometer
4. The rain gauge
5. The wind gauge
6. The wet-and-dry bulb thermometer
7. The sunshine recorder
8. A weather record
9. An average

Predicates

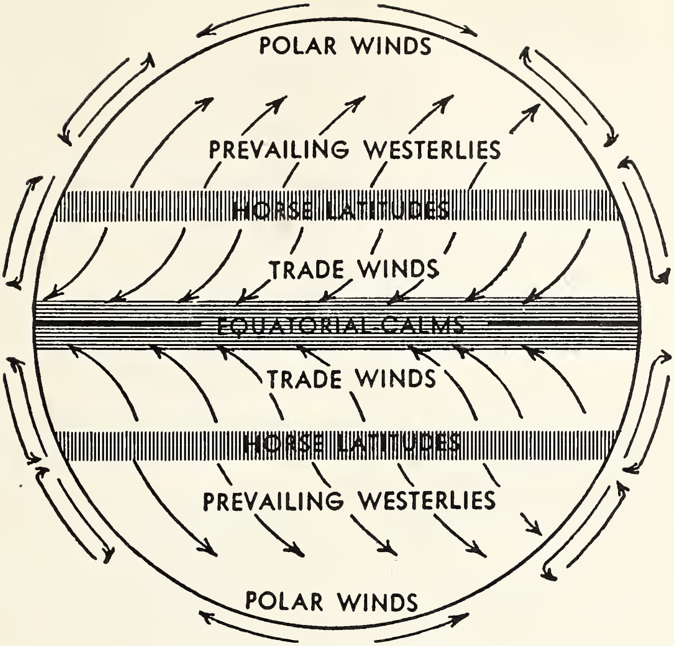
A. records high and low temperatures.
B. measures the air pressure.
C. measures humidity.
D. is of value only if based upon measurement.
E. measures the amount of rainfall.
F. makes it possible to calculate the per cent of cloudy weather.
G. is based upon large numbers of daily observations.
H. measures temperature.
I. measures the speed of wind.

3. What causes world winds to blow?

You may not see much reason to be interested in the winds which blow around the North Pole or the equator. Yet within a few weeks or months some of the same air that is at one or the other of these places may be bringing you your weather. And it makes a great deal of difference to you where it comes from. One kind of air mass might make it possible for you to play outdoors without a coat. The other kind might send you shivering along in your heaviest clothing as fast as you could go to get indoors.

Why does the wind blow? Wind blows because air in different places differs in density. That means that a given amount of air in one place weighs more than the same amount of air in another place. Cold air is denser than warm air. When cold air and warm air are present in regions close together, the cold air tends to force its way along the ground, pushing aside the warm air and creeping along under the edge of the warm air. The warm air tends to be forced off the ground and to rise.

Since the regions around the poles are colder than the rest of the world and the regions around the equator are warmer than the rest of the world, wind tends to blow from the poles to the equator. This general movement of the winds has many interruptions. Air cannot move indefinitely in one direction. It must return to the places where it comes from. The return movement of the air from the equator causes air currents high above the ground. These currents usually blow in a direction opposite



The winds of the world are broken up into clearly defined belts. Study this diagram to locate the areas of high and low pressure.

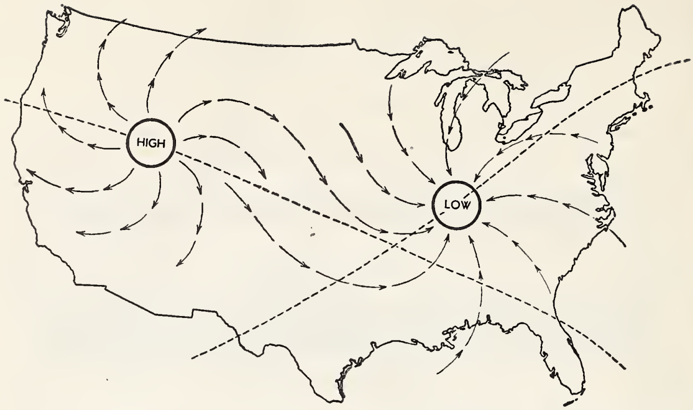
the direction of the ground winds.

You can see that this is somewhat similar to the circulation of air in a room with a hot radiator and cold window on opposite sides. Hot air rises above the radiator, flows along the ceiling, settles by the cold window, flows along the floor to the radiator.

What are the great wind belts? If we pay no attention to local winds, and take only the average direction of the larger winds, the ground winds may be seen to form wide belts around the earth. At each pole there is a great mass of cold air flowing in all directions toward the equator.

Next there is a belt of winds covering a strip extending about a quarter of the distance from the poles to the equator. These winds are blowing away from the equator toward the poles. They are generally from the southwest in the United States, and the belts are called the prevailing westerlies.

Next there is a belt where the pressure is always high, and there is very little true wind. The air settles at this belt as it returns to the poles from the equator. The air comes from the cold upper regions, and is fairly dense and cool. It spreads in both directions, some flowing away from



The area of high pressure is the center of an anticyclone. The anticyclone is sometimes called a polar air mass. The area of low pressure is the center of a cyclone. It is called a tropical air mass.

the equator to form the prevailing westerlies, some returning to the equator.

On either side of the equator are two great wind belts made up of winds blowing toward the equator. These are called the trade winds. They are hot, steady winds which meet at the equator.

At the equator there is a great belt composed of winds which are moving chiefly upward, like the hot air above the radiator. The winds in this region are so mild that it is called the belt of equatorial calms. For days there may not be enough wind in this belt to move a sailing ship.

The winds which rise at the equator continue to blow upward for three to eight or ten miles. Then they gradually spread to the north and south. They make a fairly steady air current high above the earth, flowing away from the equator. This air begins to cool as soon as it starts to rise. It cools by expanding, just as the air escaping from a bicycle tire cools. It also cools because it is high above the ground. Heat is radiated rapidly into space. By the time these air currents have returned about a third of the way to the poles, the air has cooled until it is denser than the air near the ground. This cold upper air settles and forms the horse latitudes.

The air that flows away from the horse latitude belt in the prevailing westerlies meets the cold air flowing from the poles in head-on collisions. These winds usually break up into huge masses of air. A cold air mass will perhaps break away from the North Pole, and move toward the equator. It will force its way against a mass of warmer air spreading northward from the northern horse latitude belt. The warm and cold air masses gradually slide past each other. The

cold air mass becomes warmer as it moves south, while the warm air mass becomes cooler as it moves north. At the edges of the masses of warm and cold air storms usually occur.

Why do winds blow east and west? The earth rotates, so that a place on its surface is always moving to the east. Since the atmosphere has inertia and is not firmly attached to the earth, the earth tends to slide out from beneath the air, or to leave it behind. Thus the trade winds, which blow toward the equator are easterly winds.

Sometimes the air masses in the prevailing westerly belt begin to whirl, instead of flowing smoothly in one direction. This whirl is also caused by the rotation of the earth. The air in the warm air mass tends to rise as it is pushed by colder air along its sides. Such a rising, whirling mass of warm air is sometimes called a cyclone. It is usually quite large, from 500 to 1500 miles across, and not generally very strong. The direction of the whirling air is opposite the direction in which the hands of a clock move.

A cold air mass also tends to whirl as it settles and spreads, but the direction of its movement is the same as that of the hands of a clock. The whirling mass of cold air is called an anticyclone.

The wind in a cyclone or anticyclone may be from any direction, depending upon your position in relation to the air mass.

Things to think about

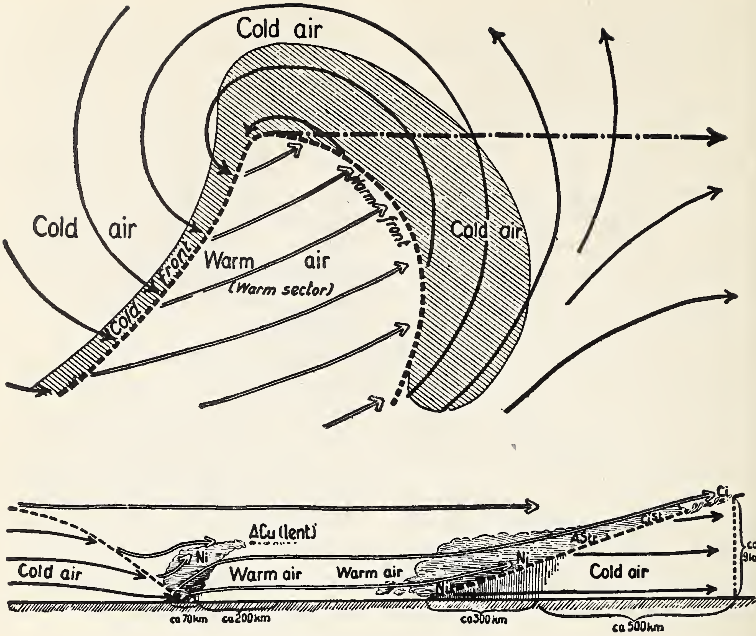
Copy the diagram of the world wind system in your notebook. Copy the following paragraph in your notebook. Complete the sentences.

The energy which causes winds to blow comes from the —1—. Air tends to flow in general from the —2— to the —3—. The wind belts in which warm and cold air masses meet are the —4—. The air pressure is always high in the —5— belt, and always low in the —6— belt. The most changeable weather is likely to occur in the —7— belt. The steadiest winds are found in the —8— belts.

4. How are the winds and rainfall related?

Each of the great wind belts has its own kind of weather. The differences result from the average temperature, and from the general direction and strength of the winds. Many local differences are caused by the presence of land or water, or by mountains.

What general conditions may produce rain? In order to have rain, or the fall of water in any other form, there must be a fairly large amount of water vapor in the air. In order for this to be possible, the wind must be fairly warm. Cold air simply cannot



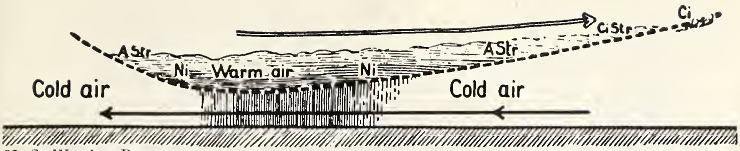
U. S. Weather Bureau

When warm and cold air masses met, the cold air pushed beneath the warm air. The shaded area (*top*) shows where the air masses overlap. The lower diagram shows a side view of the same air masses. The abbreviations indicate types of clouds. A kilometer (km.) is .6 mile. How wide is this storm area?

hold enough water vapor to produce heavy rainfall. Warm air, on the other hand, contains enough energy to evaporate water and can carry the water vapor produced.

The second necessity is that the wind must blow over some region where it may evaporate water. If the water is warm, it evaporates more readily. Such bodies of warm water as the Gulf of Mexico and the Indian Ocean give off large amounts of water vapor. Water can evaporate from the ground only if rain has fallen there previously. From the moist soil of the south and middle west large amounts of water are evaporated. Evaporation from the land cannot continue long unless the water is replaced by rain.

The third necessity for producing rain is a means of cooling humid air. Air is cooled sometimes by coming in contact with cool surfaces or objects. Where a warm and cold air mass meet and mix along the edges there may sometimes be rain from the cool-



U. S. Weather Bureau

When a mass of cold air pushes its way beneath the mass of warm air, the sky is filled with clouds and rain is probable. Can you tell what kinds of clouds are indicated by the abbreviations?

ing produced. But most cooling results when air is forced to rise. For each 1000 feet that air rises in the United States it cools a little more than 5 degrees. At the equator the cooling is about 3½ degrees for each 1000 feet it rises.

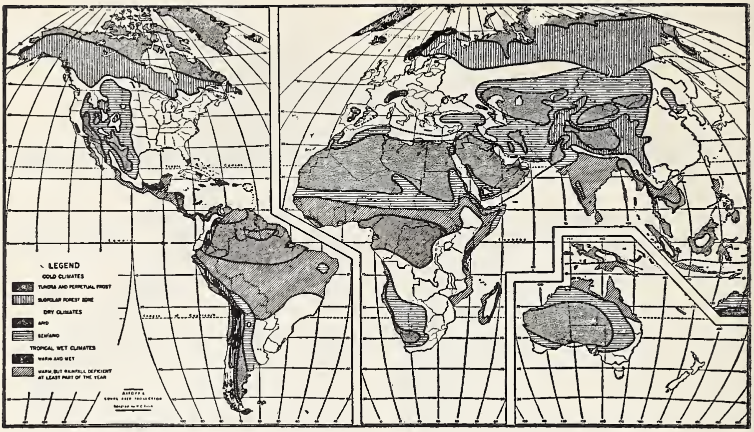
For each change in temperature of 20 degrees the relative humidity is either doubled or halved, depending on the change. If air which has a relative humidity of 50 per cent on the ground rises about 4000 feet it will be cooled 20 degrees. Its relative humidity becomes 100 per cent after this change. Any additional cooling will start the water vapor condensing.

Where do we find rain falling? Wherever humid air rises we can expect cooling. As wind blows up the slope of a mountain it is cooled. The water vapor condenses, first forming clouds, and then rain. In many regions where winds blow from the ocean over a mountain there is a heavy rainfall. The rain falls chiefly on the side of the mountain toward the wind, however.

A second place where air rises and is cooled is along the front of a moving mass of warm air. The warm air is pushed up over the spreading cold air and is cooled as it rises. Rain falls along the front of an advancing mass of warm air.

A third place where warm air is cooled by rising is in columns of up-sweeping air. In tornadoes and hurricanes the rising air whirls violently and the air rises very fast. The water vapor may condense in the form of hail or rain. A similar action, but without much whirling motion, occurs in thunderclouds. A column of warm air starts billowing upward, cooling as it rises. The rainstorms resulting from this type of action may be very violent.

A fourth place where air rises is in the belt of tropical calms. Almost every afternoon heavy downpours of rain occur in the equatorial tropics. It seems strange that rain falls because of cooling in the hottest regions of the earth. Where the rains form it is not hot, however. Even above the equator the temperature at the base of the stratosphere may be 50 degrees below zero, or even colder. Since the air in the trade winds generally



U. S. Weather Bureau

By studying this map, you can determine what parts of the world have climates unfavorable in some way to settlement. Only the white land areas are highly favorable to human life.

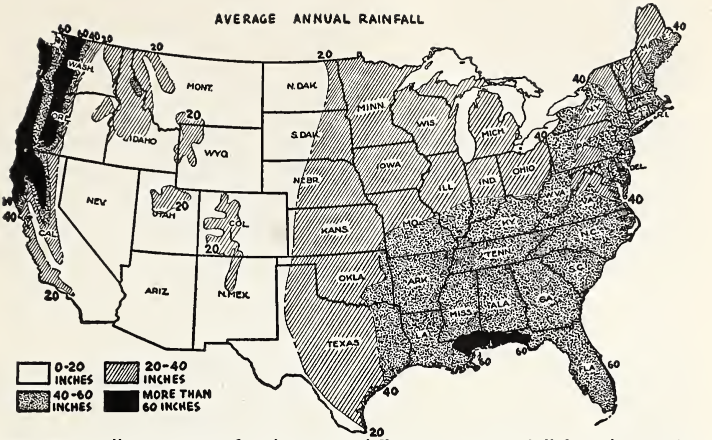
blows over the ocean, it is usually humid. Even a slight cooling will often produce rain in the tropics. It may even rain on the sides of low hills toward the wind.

What causes drying winds? When a wind is becoming warmer, it is a drying wind. If the temperature of the wind increases 20 degrees, it can absorb twice as much water as before. You know from common experience that the air above a hot radiator will dry clothing faster than will the air beside a cold window.

A wind is drying if it blows from a region where there is not much water free to evaporate. A wind that has its start over a desert or over the polar ice caps has little chance to absorb water vapor. When it comes to a place where there is water it will evaporate and absorb more water than a more humid wind would.

Where do we find drying winds? Drying winds occur under conditions the opposite of those which cause rain. When a wind blows down a mountainside it becomes warmer, and thus is a drying wind. Many of the American deserts are caused by winds blowing down the Coast Range of mountains. The Great Plains are dry because wind blows from the Rockies.

An interesting down-draft wind is the western chinook. When a wind has blown up a mountain slope, most of its water vapor is lost. Then it may blow down the east side of the mountain, being warmed by going to a lower elevation. A chinook may increase the temperature of a given place as much as 40 degrees in a quarter of an hour, and may melt a foot of snow in a few hours.



There are excellent reasons for the great differences in rainfall found in various parts of the United States. Do you know what they are?

The second great group of drying winds are those blowing from colder to warmer regions. Most polar air masses—those winds or masses of air coming from above the great glacial ice caps—can only become warmer as they move toward the equator. And of course they are drying winds because they absorb moisture from regions over which they blow.

Sometimes a mass of air settles as it cools, and thus becomes warmer. A settling mass of cool air is likely to be somewhat drying.

In the horse latitudes the winds returning from the equator settle from the cold upper regions to the warmer ground. All around the earth there is a belt of dry semidesert or desert regions where these winds absorb moisture from the ground. The north part of the Sahara and part of our own southwestern deserts are caused by the horse latitudes. During part of the year the horse latitudes move north into the central United States. The hot, dry weather of late midsummer is not an accident, but an expected result of having the horse latitudes move into our own territory.

DEMONSTRATION: IS AIR COOLED BY EXPANSION?

What to use: Small air pressure pump, large flask or bottle, glass and rubber tubing, string, stopper to fit flask. A bicycle pump may be used if a valve stem is inserted in the rubber tubing.

What to do: Put an inch of moderately warm water in the bottom of the flask. The flask should be fairly warm. Rinse the water around the inside of the flask to increase the surface from which it may evaporate. While waiting for the air in the flask to become humid, connect the pump with tubing to the flask, so that air may be pumped

into the flask. Tie the stopper loosely to the flask with the string.

Pump air strongly and rapidly into the flask, so that it blows out the stopper. Observe closely the cloud that forms in the flask as the air expands when the stopper blows out.

Breathe into the flask until you make it cloudy looking. Pump air into the flask until the cloudiness decreases.

What was observed: How much force did the stopper seem to have? How noticeable was the cloud? How long did it last? Why did it disappear?

What was learned: What happened to the pressure in the flask when the stopper blew out? What change in temperature occurred? What effect did the temperature change have upon the water vapor in the flask?

Things to think about

Make a table by ruling your paper into two columns. Head the columns as follows: DRYING WINDS, RAIN-PRODUCING WINDS. In the correct columns write the following groups of words: blow down mountains, rise at the equator, are found in cyclones, are found in the horse latitudes, blow from cold to warm regions, blow up mountain slopes, develop in thunder-clouds, blow from deserts, accompany tornadoes, accompany high-pressure air masses, include the chinook.

5. Why do seasons change?

In the northern United States no factor has so much to do with the condition of the atmosphere as does the season. The same pond may be used for skating and for fishing, depending on the season. The ground may be frozen to a depth of four feet, or it may be so hot that you could not walk on it barefooted.

Summer is generally spoken of as the warm season, and winter as the cold season. For most of the United States the difference in season is based on temperature. In other parts of the world the different seasons may be based on the amount of rainfall. Instead of having warm and cold seasons, they have wet and dry seasons. In our latitudes we receive less light from the sun during the cold season than we do in the summer, and farther north this difference is even more pronounced. People who live there speak of the dark season and the light season.

How does sunshine vary with seasons? The angle at which the sun shines determines to a large degree how much heat we receive. The tropics are considered to be that part of the earth where the sun is directly overhead at noon at least one day a year. The lines which mark the boundaries of this zone are also called tropics. They are 23½ degrees on either side of the equator. At the northern limits of the tropics the sun is directly overhead in our summer, but is far to the north of the southern tropic. In our winter the situation is reversed.

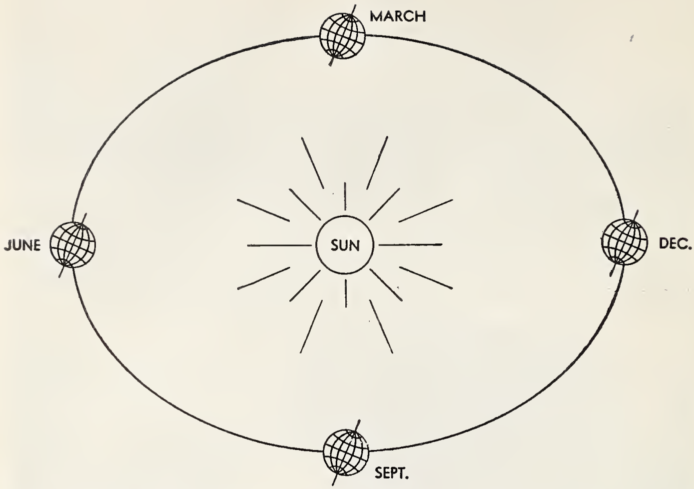
Only on March 21 and Septem-

Living things respond to the change in seasons. This scene photographed in winter and in summer shows how trees and shrubs change in appearance.

ber 22 does the light of the sun touch both poles at the same time. During our summer more and more of the area around the North Pole becomes warmed by the sun. On June 21 all the area within the Arctic Circle is in sunshine for 24 hours, and the entire area within the Antarctic Circle is in total darkness for 24 hours. In our winter this situation is reversed. The Arctic and Antarctic circles are $23\frac{1}{2}$ degrees from their poles.

It is not too difficult to understand just why the amount of sunshine and the length of day and night vary with the seasons.

Why does the length of days and nights differ? We have already learned that day and night are caused by the rotation of the earth. If the earth's axis were always at right angles to the plane of revolution of the earth about the sun as the earth turns, days and nights would be of equal length, regardless of where we might be. However, the axis of the earth is always tilted at an

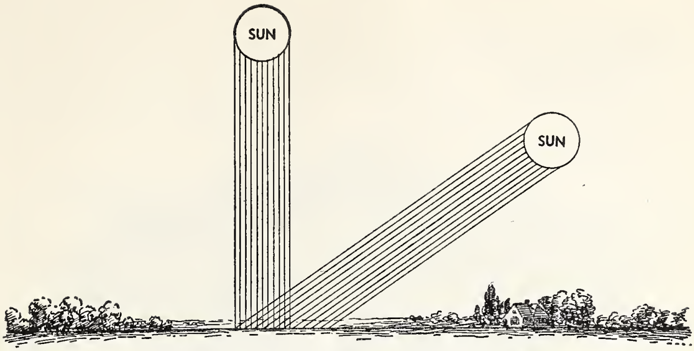


The axis of the earth always points toward the North Star. Because of this, the revolution of the earth causes first one pole and then the other to be inclined toward the sun.

angle of 23½ degrees and always points to the same place in the sky. This place is near the North Star. Consequently, as the earth revolves about the sun, sometimes the North Pole leans toward the sun and sometimes the South Pole is toward the sun. When the North Pole is closer to the sun, the half of the earth's surface lighted includes some area beyond the North Pole; so that the time required for a point on the earth's surface to travel through the half which is lighted is greater than would be required for the same point to move through the portion which is not lighted. Therefore the days will be longer than the nights.

As the earth advances one-fourth of the way around its orbit, the axis, although tilted sideways, is perpendicular [straight up and down] to the plane of revolution. At this time light shines equally on the two polar regions, and the time required for the earth's rotation to carry us through the light and dark zones is exactly equal.

When the earth has traveled a quarter of the distance around its orbit, the North Pole is inclined away from the sun, and a smaller part of the northern half of the earth will be lighted. During this period we have short days and long nights. Part of the region around the North Pole actually does not receive any sunlight, so that during that time it is always night. When the North Pole is inclined toward the sun, light shines over all of the polar area, both day and night. For this reason the country is known as "the land of the midnight sun."



The direct rays of the sun give more heat than do the slanting rays. The sun is more directly overhead in summer and at noon.

Where does the sun rise and set? While it is a common statement that the sun rises in the east and sets in the west, there are actually only two days in the year when this is exactly true. These two days are September 22 and March 21. During the rest of the year it rises either north of east or south of east, depending upon whether it is summer or winter.

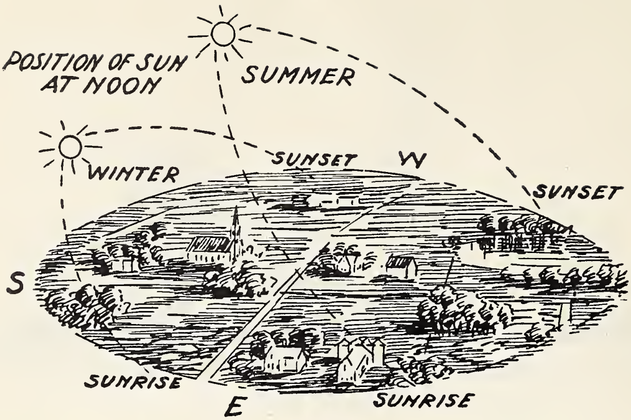
What causes the seasons? During the winter the sun is closer to the earth than it is in the summer by more than two million miles. At first thought it would seem that it should be hotter in the wintertime. However, a difference of two million miles is not enough to make much difference in the amount of heat which we receive.

The most important difference between summer and winter comes from the angle at which the sun's rays strike the earth's surface. If the sun is directly overhead, a square mile of surface receives a greater amount of the sun's heat than it will if the sun's rays strike this surface at an angle. The sun's rays come from more directly overhead in summer than in winter.

You can discover why this is true by doing a very simple experiment with a flashlight and a piece of cardboard. Hold the flashlight at a distance of three feet from the cardboard so that its rays are at right angles to the cardboard. Measure the diameter of the ring of light which it makes on the cardboard. If you will then turn the cardboard so that the light strikes at an angle and measure the diameter of the lighted ring, you will see that the same amount of light is now scattered over a much larger area.

The length of time which the sun shines on the earth is also an important factor in causing seasons. The sun not only shines more directly during the summer, but it also shines for more hours.

The amount of heat absorbed in the day is lost in the night, if



Only on two days each year does the sun rise in the east and set in the west. This diagram shows the actual path of the sun through the sky on December 22 and June 21. Where does the sun rise and set on these days?

the nights are long enough. Since summer nights are short, there is some heat left each morning. Each day more heat is added, gradually raising the temperature until midsummer heat is reached. The hottest day in the year comes later than the longest day. The hottest part of the summer usually comes in August. The accumulation of heat continues until the nights become sufficiently long for the earth to lose as much heat as is being added in the daytime.

In wintertime more heat is being lost at night than is received during the day. The coldest day comes later than the shortest day. It does not begin to get warmer until the amount of heat received is equal to or greater than the amount lost during the night. Thus we see that there is a natural explanation for the lag of seasons.

DEMONSTRATION:
HOW DOES THE ROTATION AND REVOLUTION OF THE EARTH CAUSE A CHANGE IN SEASONS?

What to use: Flashlight, small globe.

What to do: Let one pupil find out how much the axis of the globe is to be tilted to be 23½ degrees. As he walks around in a circle, let another pupil stand in the center of the circle, directing a flashlight on the globe, which is being held with its axis always pointing in the same direction at the angle of 23½ degrees. Mark your latitude and slowly rotate the globe on its axis. You will be able to see how the time you are exposed to the light varies in different positions about the circle.

What was observed: Where in the circle did the upper axis receive the most light? Where did the lower axis receive the most light? In what position was the period of rotation the same for your location on the lighted surface and the dark surface? What

would conditions be like on different parts of the earth if it were to stop revolving but continued rotating? Let the pupil carrying the globe stop so you can see what would happen. Where on the globe would the light from the flashlight give the greatest illumination?

What was learned: Answer the questions above.

Things to think about

Match the following subjects and predicates. Copy the sentences in your notebook.

Subjects

1. December 22
2. Winter
3. Spring
4. Summer
5. Autumn
6. June 21
7. The change of season
8. The earth's axis
9. Variation in day and night

Predicates

A. is the longest day of the year.
B. is the shortest day of the year.
C. extends from September 22 to December 22.
D. extends from June 21 to September 22.
E. extends from December 22 to March 21.
F. extends from March 21 to June 21.
G. depends upon revolution and inclination of the earth's axis.
H. depends upon rotation, revolution, and inclination of the earth's axis.
I. is inclined at an angle of $23\frac{1}{2}$ degrees.

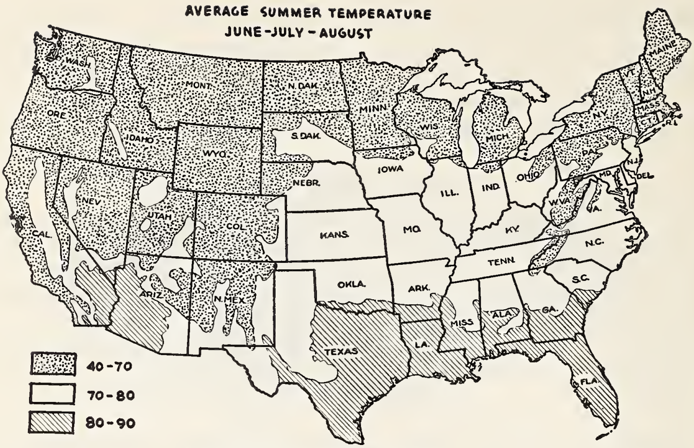
6. How do changing seasons affect weather?

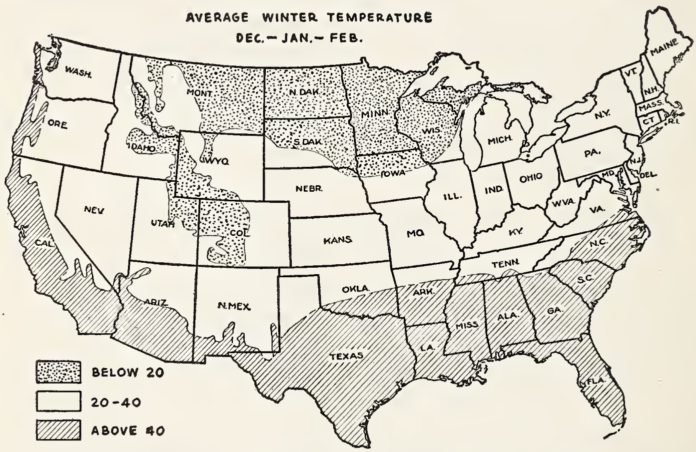
If you could somehow live in many places on the earth at the same time, you would find that the changing seasons do not bring to all other regions just the same changes that we have in the United States. Even in different parts of the United States seasonal changes may bring greatly different kinds of weather.

Do the winds change with the seasons? When we studied the world wind system, we discovered the average positions of the wind belts for the whole year. But the wind belts do not stay fixed in one place. They move or "follow the sun." The belt of tropical calms actually lies above the heat equator, and not the real equator.

The heat equator is a line drawn around the world, extending through the hottest places instead of those equally distant from the poles. The heat equator is never a straight line. Its average position follows the real equator only approximately. It bends to the north in Africa at the Sahara desert, and in North America it bends to the north almost to our southwestern desert states. Near Australia it swings south of the equator until it almost touches that continent.

The heat equator shifts north in our summer, but about a

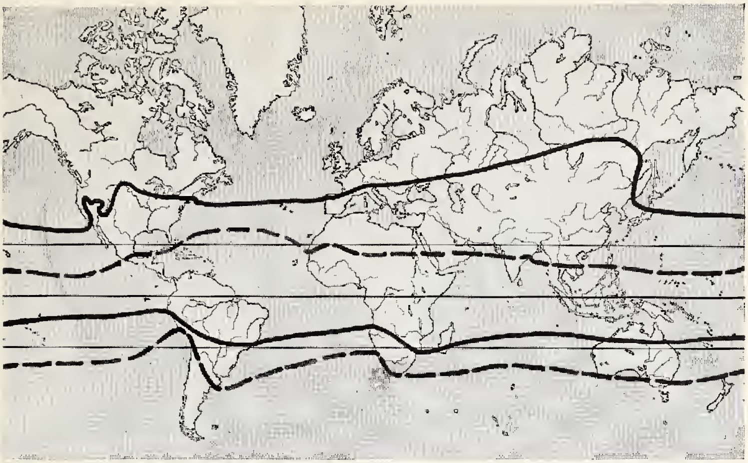




The yearly average of temperature is not so important for comfort as the temperature of a given season. The summer temperature of the various regions (*top*) is affected by latitude, altitude, and distance from the ocean. The winter climate (*bottom*) follows zones different from those of the summer zones. What region is cool in summer and warm in winter? What regions have extreme temperatures? What regions are cool all the time? Warm all the time?

month more slowly than the sun shifts. That is, while the sun reaches its northernmost point directly overhead on June 21, the heat equator reaches its most northern limit in the last half of July. In the same way there is a lag as it moves south. The hottest part of the southern summer comes in January, and not in December.

The entire system of world winds shifts with the heat equator and the belt of calms. In sum-



In July the entire area between the solid lines has an average temperature of more than 70 degrees. In January the area between the broken lines has an average temperature higher than 70 degrees. Notice that neither set of lines follows the tropics.

mer the trade winds move farther north. The prevailing westerlies move farther northward into Canada. In winter the arctic cold air zone extends south into northern Canada. The prevailing westerly belt moves south and extends over all the United States. These changes occur in the southern hemisphere at the time of year opposite ours.

Do changing winds bring changing weather? Of course the most important cause of differences in summer and winter weather is the difference in the amount of heat a region receives from the sun. For each 62.5 miles that one travels north or south of the equator the average temperature decreases one degree. But extreme seasonal differences in temperature at a given place in the United States may be almost as great as the difference between the temperature at the equator and one of the poles on a given day.

The average elevation of the sun in the northern states in summer is 70 to 75 degrees. In winter the elevation is only 20 to 25 degrees. Thus we have such great differences in temperature that even warmer or colder winds have much less effect than do the differences in temperature caused by the amount of heat we receive from the sun. In the United States a warm winter day is usually colder than a cool summer day.

In the tropical regions, however, winds bring more important changes in seasons than do differences in heat received from the sun. There is no winter in the tropics. The seasons are the rainy season and the dry season. The rainy season arrives when

the belt of tropical calms moves into a certain region. If this place is more than 10 degrees north or south of the equator, the rainy season will arrive in the late summer. It will be considerably shorter than the dry season.

Places not more than 10 degrees from the equator have two rainy seasons and two brief dry seasons each year. The belt of equatorial calms swings so far north and south that it leaves this strip of the earth near the equator twice a year. The rainy seasons of the equator come in our spring and fall, for it is at that time that the sun is directly overhead at the equator.

The belt of equatorial calms is so wide that it covers the strip of earth more than 10 degrees from the equator and inside the tropic toward which it is moving. While in a way this strip may have two rainy seasons, they blend together into one. You might say that the belt of equatorial calms meets itself going back.

Do we have different kinds of winds in summer and winter? During our winter months the northern part of the interior of our continent becomes cold and is almost like an extension of the north polar zone, as far as winds are concerned. There is little heat to evaporate water and not much to warm the air. The prevailing westerly winds returning from the horse latitudes are constantly bumping into and pushing against the cold air mass which forms in the center of the continent. Sometimes one of the warmer air masses pushes its way far inland from the Gulf or the Pacific. Where these masses of air meet, the warm air is forced to rise, but instead of producing rain this warm air mass usually brings snow. The United States is a large region where the two kinds of air masses are constantly pushing against each other. We have storms along the fronts of these air masses.

During the summer the continent becomes very hot. Then the air masses tend to be like those of the tropics. They tend to rise and may produce many local showers. There is enough heat to evaporate much water, but water which is evaporated from the soil often condenses and falls as rain someplace else. The heat from the sun makes the summer air hot. The polar air masses are not so cold and heavy as in winter, and do not push their way so far south. Cool air masses do, however, move in from the ocean, bringing water vapor with them. These air masses are far from cold, but still are cooler than the air masses formed over the land.

You may think that the relation between winds, weather, climate, and seasons is quite complex and difficult to understand. Your belief would be correct. There is no simple explanation of weather at any given place or time. Weather experts are studying the weather from all parts of the world from which reports may be obtained in order to learn to predict our daily weather more accurately.

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

A line extending around the world through the hottest points is the —1—. This shifts to its position farthest north about —2—. The wind zone which invades our southern states in summer is —3—. The most important cause of differences in seasons in the United States is the —4— of the sun's rays. In the tropics the two seasons are the —5— season and the —6— season. The —7— season occurs when the belt of equatorial calms passes over the region. Many of our violent winter storms occur along the —8— of warm air masses. The air mass which lies over the center of the continent in winter is —9— and in summer it is —10—.

A review of the chapter

We have learned that our atmosphere is constantly moving because of differences in the amount of heat it holds. The energy which causes air movement comes from the sun and from the rotation of the earth. Cold air can push aside and force its way under warm air. Warm air tends to rise, while cold air tends to settle. The general movement of air along the ground is from poles to the equator. At heights of several miles above the earth the air tends to flow from the equator to the poles. This even flow of air is often interrupted, so that there are several wind belts and belts of little air movement extending around the world. These wind belts shift north and south with the changing seasons, so that one place may be in more than one wind belt at different times of the year. The changes of the season which are produced by the tilting of the earth and its revolution around the sun bring great changes in weather in the United States. The shifting of the world winds also produce changes in our weather.

We have numerous accurate scientific instruments that we use for measuring and predicting various weather conditions.

Word list for study

Be sure that you can pronounce, spell, define, and use in a sentence every word in this list. Each of these words has been defined or explained and used in this chapter.

atmosphere	humid	air mass
stratosphere	absorption	fixed point
maximum	minimum	thermograph
barometer	velocity	hygrometer
density	trade winds	prevailing westerlies
horse latitudes	cyclone	anticyclone
relative humidity	tornado	hurricane
chinook	tropic	arctic
antarctic	heat equator	elevation

An exercise in thinking

Below are two groups of sentences. The first group contains principles, which are large general ideas. Each sentence in the second group contains an idea related in some way to one of the principles in the first group. Write the numbers from 1 to 32 on a piece of paper or in your notebook. Find the principle which best explains the idea in the second list. Then after the number on your paper write the letter before the related principle.

List of principles

A. The more nearly the sun's rays strike a surface at a right angle, the greater is the amount of energy received by the surface.

B. Rotation of the earth causes air movement.

C. The general direction of air movement is from cold to warm regions.

D. As warm air rises it expands and is cooled.

E. As cold air settles it is compressed and becomes warmer.

F. As air becomes warmer its ability to hold water vapor increases.

G. As air becomes cooler its ability to hold water vapor decreases, until a point is reached at which water vapor condenses.

H. Change of seasons is caused by inclination of the earth's axis and by its revolution around the sun.

List of related ideas

1. Heavy rain falls where air rises in the belt of equatorial calms.
2. Air is warmed in the horse latitudes.
3. World winds generally blow from the poles to the equator.
4. Trade winds are easterly winds.
5. The sun shines on all areas within the Arctic Circle on June 21.
6. Increasing air pressure in a flask causes a vapor cloud to disappear.
7. Air is cooled in the equatorial belt of calms.
8. Summer sun is hotter than winter sun.
9. The sun is overhead at the equator in March and September.
10. Air above the Gulf holds more water vapor than does polar air.
11. The chief movement of winds is northward or southward.
12. The hottest regions are near the equator.
13. Winds cool as they blow up mountains.
14. Winds become warmer as they blow down mountainsides.
15. Rain may fall on a mountain while the valley remains dry.
16. The winds of the United States are generally westerly winds.
17. Air pressure is high where air currents are falling.
18. Air currents move downward in the horse latitudes.
19. A south slope of a hill is warmer than a north slope.
20. On December 22 the sun

reaches its point farthest south.

21. The trade winds are usually drying winds.
22. A barometer reading falls where air is rising.
23. Winds in a high-pressure area rotate clockwise.
24. Winds blowing over mountains lose much of their water vapor.
25. Winds blowing from the Coast Range have created large deserts.
26. Air cools 3 to 5 degrees for each 1000 feet it rises.
27. Winds in low pressure areas rotate counterclockwise.
28. In a closed room air flows from cold windows along the floor to hot radiators.
29. As a warm air mass rises above cold air, clouds usually form.
30. Air in cold air masses warms as it spreads on the ground.
31. If the earth's axis did not tilt, we would have no seasons.
32. The angle of the sun above the horizon determines how much heat we will get from it.

Some things to explain

1. What are some advantages in having cold winters?
2. Why are many famous resorts located in desert regions?
3. How does the earth's wind system compare to circulation in a hot-air heating system?
4. What is the most useful instrument for predicting weather?
5. What is the most useful single record needed to describe climate?
6. Would it be pleasant to live on a mountain in the tropics?

Some good books to read

Baer, M. E., *Rain or Shine*

Bradley, J. H., *Autobiography of the Earth*

Brooks, C. F., *Why the Weather?*

Gaer, J., *Fair and Warmer*

Longstreth, T. M., *Knowing the Weather*

Meyer, J. S., *Picture Book of the Weather*

Sloane, E., *Clouds, Air, and Wind*

Spitz, A. N., *Start in Meteorology*

Writers Program, *Ladder of Clouds*

CHAPTER

10

Our Earth's Climate

It seems that no matter what kind of climate a region may have, someone is willing to live there. Even in deserts and in swamps a few people somehow manage to find a living. But be-

The glaciers which once covered large areas of the world have now melted away until now only smaller glaciers are found on mountains and in the polar regions.

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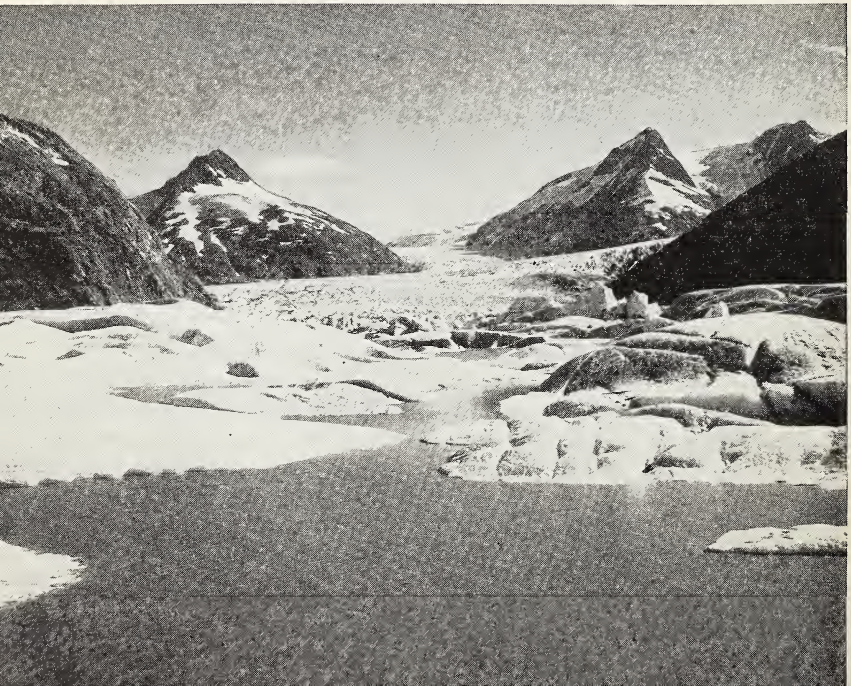


In the foreground low rain clouds and rain nearly obscure the funnel of a tornado cloud in the distance.

fore a region can support a large population in comfort and security, its climate must be good.

A good climate provides enough rainfall for a water supply and for farming. It provides warmth during part of the year for growing crops and for the growth of animals. A good climate provides conditions more favorable for man than for his enemies.

Some climates are good in most respects, but not in all. A warm climate may provide excellent conditions for crops and for comfort, but will not become cold enough to kill insect enemies. Another climate may be healthful, but so cold that the cost of living is higher than it would otherwise be.

It is desirable to find a climate in which one can live in comfort and where costs of fuel and clothing are not too high, but these conditions are not necessary. Many people live in places that have uncomfortable, cold climates. In spite of the climate, they are prosperous and healthy. People live where there is so little rainfall that without irrigation nothing would grow, yet some of the best farms are found in these dry regions. It is apparent that we can adapt ourselves to various types of climates.

Our ability to live in different climates is fortunate, for the United States provides us with many kinds of climates in which to live.

Some activities to do

1. Keep accurate records of the temperature for several weeks. Take the temperature reading outdoors at the same time each day.

2. Obtain weather maps from newspapers and compare the weather you have on a given day with the condition of the atmosphere as indicated on the map. Keep records of observed cloudiness, relative speed of the wind, amount and kind of precipitation, and compare your records for several days with the predicted weather.

3. The Weather Bureau sometimes uses signal flags to indicate to small-boat shipping the probable weather. Make a set of these flags and label them.

4. On an outline map of the United States make a temperature map. Color the hotter regions red, the moderate regions yellow, and the cooler regions blue.

5. On an outline map of the United States, make a rainfall map. Select suitable colors to show the various regions.

6. Obtain recent information about symbols used on weather maps. Make a chart showing these symbols for the bulletin board.

Some subjects for reports

1. The best climate for a summer vacation

2. The best climate for a winter vacation

3. The best year-around climate in the United States

4. Good and bad features of your local climate

5. Life in the Amazon valley jungle

6. Desert life and vegetation

7. Eskimo life

8. New methods of measuring weather changes

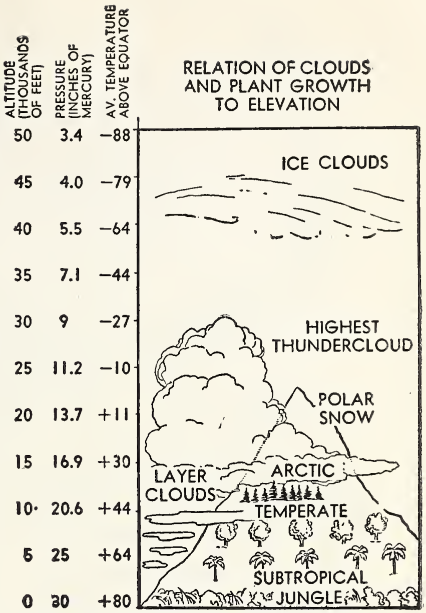
9. Record making weather in the United States

1. What is climate?

The factors which make up climate are the same as those which make up weather. The most important factors are wind velocity and direction, temperature, and rainfall. Others are the amount of fog; the number of days free from killing frosts; the frequency of violent storms; the number of hours of sunshine; the number of days snow covers the ground; the average "ceiling" [height of clouds]; and the frequency of floods. Even the amount of pollen in the air is reported as a part of the climate.

How does latitude affect the climate? Latitude is the distance on the earth from the equator. As you already know from studying the relation of the earth to the sun, those parts of the earth are warmest where the sun shines from directly overhead. These regions, which lie between the lines on the globe called tropics, do not extend to the United States. Our climate is greatly influenced by latitude, however, for the sunshine strikes the earth at a much more direct angle in the southern than in the northern states.

As a result of the differences in the angle of the sun's rays to the earth's surface, the temperature becomes cooler as one goes away from the equator. There are also



Study this diagram to learn how temperature, air pressure, growth of plants, and cloud formations are related to elevation.

great differences in temperature as the seasons change. When we are quite far north, the differences in the angle of the sun's rays cause very great differences in temperature. The two maps, showing the average temperatures of the United States in summer and winter, show clearly how greatly summer and winter temperatures vary. (See p. 336.)

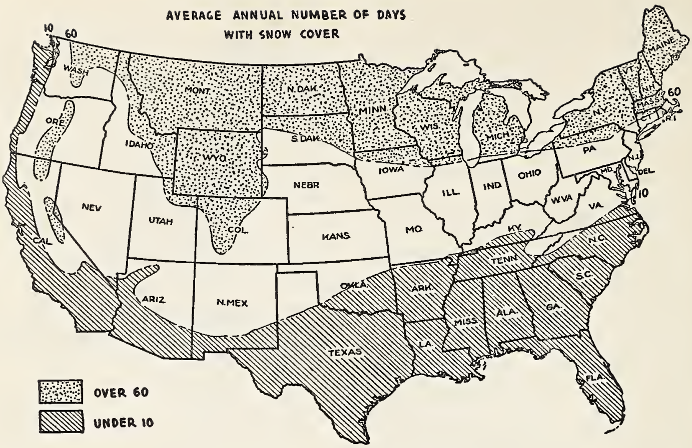
On the average, the farther one goes from the equator, the greater are the differences between summer and winter.

How does altitude affect the climate? Careful study of the two temperature maps shows that the lines running through points of equal temperature, called isotherms [ī′sô-thûrms], run from east to west in general. This is what we would expect, for as one goes north it becomes colder. Yet in the regions of the Rocky Mountains and the Appalachian Mountains, the lines tend to run north and south. The mountains are colder than the lowlands.

It has been found that the average decrease in temperature as one goes up on a mountainside is one degree for each 330 feet of increase in altitude. This difference causes much more rapid changes in climate than do the differences in latitude. All the kinds of climate that usually are only found hundreds of miles apart may be seen on the sides of a high mountain.

At the foot of a mountain there may be flowers in bloom from May until November. A few hundred feet higher the season is shorter, and farmers raise quick-growing crops, such as potatoes and oats. There are alders, birches, and fir or pine trees at a higher elevation. A few hundred feet higher are found fir and spruce trees—the kind of trees that grow in southern Canada. Still higher are only low shrubs, such as mountain laurel. Above this is bare rock, and still higher is the eternal snow of glaciers—the climate of the arctic type.

The permanent snow line in the southern states is at an altitude of 8000 to 10,000 feet, and in the northernmost states at an altitude of about 6500 feet.



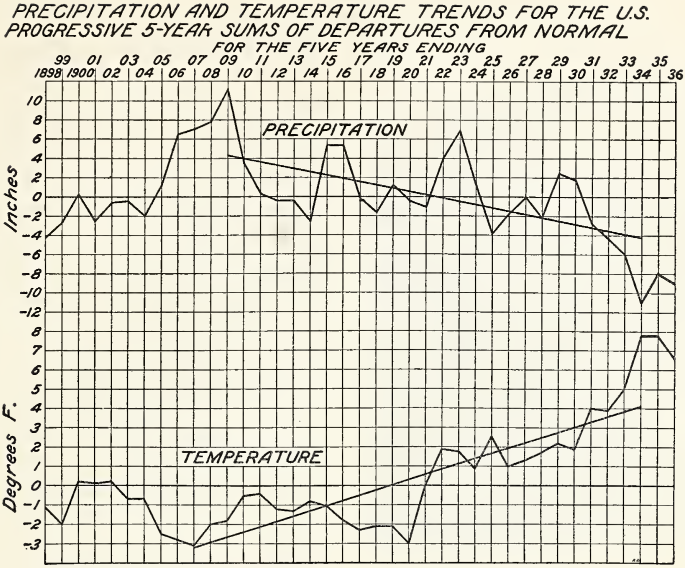
This map shows how long snow stays on the ground. Explain why the 60-day zone dips so far south into Colorado and Utah. Why does it move north in South Dakota and Washington?

How does nearness to water affect climate? You know that water holds more heat than any other common material of the earth. For this reason the lakes and the ocean warm up more slowly than does the land. As cooling takes place, this larger quantity of heat in water is more lasting than the heat supply of the land. Another factor making the ocean more even in temperature is the circulation of the water. Land cannot circulate.

From season to season the temperature differences of regions near the ocean are much less than those of inland regions. The direction of the wind is an important factor in determining how much is the effect of bodies of water on the land. If you study the summer temperature map, (page 336) you can see that the entire Pacific Coast is in the cool zone, while the Atlantic Coast is not. In the winter the Pacific Coast is in the warm zone, and the Atlantic Coast is not. The explanation is that the winds of the United States blow from the west, carrying to the Pacific Coast the type of temperature that is typical of the ocean. The general wind movement along the Atlantic Coast is from the land, so that the climate of those states is the same as that of the interior of the continent.

The effect of water in warming the land can be seen in the winter temperature map, for it is the states farthest inland—and those with the highest altitude—that have the coldest winters. Can you see any effect of the Great Lakes on the temperature?

How important is each factor in determining climate? In any given place, one factor may be



U. S. Weather Bureau

From 1908 to 1934 the temperature of the United States increased and the amount of rainfall decreased. This comparatively short period is insufficient to indicate a permanent trend.

more important in determining the climate than it is on the average over the country as a whole. For instance, along a mountainside the altitude may be the most important factor. But in general, latitude is the most important factor affecting climate. No one factor can be considered the only cause of climate.

The amount of rainfall in a given place depends upon several factors. They include the slope of the land in relation to the wind, the nearness to the ocean, and the temperature.

Air which is falling is being compressed. As air is compressed it becomes warmer. As air is warmed, it may form a drying wind. Air which is rising is expanding. Expansion cools air and may cause it to form a rain-producing cloud.

Regions near the ocean usually have more rainfall than do those far inland. On the average, the colder regions have less rainfall than the warmer regions, for heat is required to evaporate water. In the colder regions there is not as much water vapor in the air to fall as rain.

The length of time snow remains on the ground depends upon the temperature and upon the amount of snow that falls. No matter how cold a climate a region may have, the ground will not be covered with snow if the

Wearing a sun helmet and working in the sticky, humid air of the tropics, a weather observer operates a theodolite to check the flight of a balloon.

air is too dry to bring moisture. Yet, on the average, the snow lies on the ground in those regions where the winter temperature is just below freezing or lower, because most regions have at least a small amount of snow. In the upper central states the same snow may stay all winter.

Wind velocity depends upon differences in temperature from one region to another, and upon the rotation of the earth.

How do local conditions affect climate? The presence of valleys, mountains, and lakes may cause the climate of a small area to be considerably different from that of the larger surrounding region. The temperature maps do not show the location of each small mountain peak in the west or the location of deep valleys in the central states. Yet these mountains and valleys produce differences both in temperature and in the number of days that snow covers the ground. On the summer temperature map the shaded areas in West Virginia and North Carolina are mountains. The white areas in Washington, Idaho, and Utah are low valleys and are almost, or entirely, desert regions. Even the clouds of smoke above cities may affect their climates.

Is the climate changing? The records of the United States Weather Bureau extend over a period of 50 to 100 years, depending upon the location of the station reporting. In this period of time it has been found that for a few years the climate becomes warmer and drier. Then for another period of a few years it becomes cooler and moister. But there is no evidence to show that within this entire period there is any definite change one way or the other.

It is entirely probable that within the next few thousand years the climate will become warmer and drier, because the last glacier that covered the northern states about 25,000 years ago is still slowly melting away. No one knows this as a certainty, however, for the conditions which produced the great glaciers may return and cause a change in the climate in the opposite direction.

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

The temperature becomes one degree lower for each —1— feet increase in altitude. Mountains have —2— temperatures than near-by plains. The —3— coast climate is greatly influenced by nearness to the ocean. The rainfall is heavier on the side of a mountain —4— the wind. The lines which run through points of equal temperature are called —5—. The number of days of snow cover where I live is about —6— (see map on page 346); the average winter temperature is about —7—; and the average summer temperature is about —8—. The chief factors influencing the climate where I live are —9— and —10—.

2. What is a tropical climate?

Like all the other climates, the tropical climate varies from place to place. Regions between the lines called the Tropic of Cancer and the Tropic of Capricorn are generally considered to have a tropical climate. But some places outside this area have more nearly tropical climates than do other places within the tropics. Sometimes this region is called the torrid zone, because it is always hot.

How hot are the tropics? Except for places of high elevation, the whole region within the tropics has a high yearly average temperature. No place where the average falls below 68 degrees is to be considered to have a true tropical climate. Much of this tropical region has a yearly average temperature of 80 degrees or higher.

The jungle regions of the tropics are produced by heavy rainfall and by high temperatures. The temperatures may average from 90 to 100 every day and almost every hour of every day. It may not be more than two or three degrees cooler at night than it is in the middle of the day in the shade. The coolest part of the year may be only two to five degrees cooler than the hottest part.

In the deserts there is much greater range of temperature. A temperature of 136 degrees has been recorded in the north Sahara desert. Temperatures above 110 degrees are common in all tropical deserts. The nights are cool, or even cold. There may be freezing weather in the Sahara desert. The lack of clouds, vegetation, and water permits the heat to escape rapidly. Sand and rocks do not hold heat well compared with water. Clear air permits heat to radiate into space much more rapidly than does cloudy air.

Along the edges of the tropics the climate becomes more like that of our extreme southern states. Along the edges there is a noticeable difference in temperature from season to season.

What are rainfall conditions in the tropics? You know that the belt of equatorial calms lies

U. S. Weather Bureau

These two balloons carry radio equipment into the air. Signals broadcast to the weather station give information about the upper air. When the balloons rise high enough, they burst and the radio is lowered to the ground by the parachute.

entirely within the tropics, even though it moves north or south with the seasons. In the low regions of central Africa and Brazil the two wet seasons are so close together that there is no drying of the land at any time. While the winds are low, there are sometimes thunderstorms and quick updrafts of air. These bring heavy downpours of rain. In some parts of the tropics there is heavy rainfall almost every day of the year. The rain usually falls in the afternoon.

In places more than 10 degrees from the equator the dry season is longer than the rainy season. Sometimes a region will become almost like a desert. The vegetation dies, the ground becomes dusty. Rivers and waterholes shrink. The afternoons are so hot that few white people can work at that time. Then one day the rains start. Terrific downpours may wash great gullies in bare hillsides. There are violent thunderstorms. The earth turns green almost within a day. The seemingly dying plants recover their vigor.

India and some other regions have a monsoon wind. A monsoon wind changes direction with the season. In the wet season it blows from the ocean to the land. There it rises as part of the equatorial belt of calms. The chief wind in a monsoon region is a trade wind. The hot land gives air heat which causes it to rise faster than usual. Air is swept in from the ocean bearing more

water vapor. Where there are mountains which increase still further the tendency of this hot air to rise, there occur the world's heaviest rains. During the dry season in India the belt of calms moves southward away from the land, and the wind blows from the land to the ocean.

Within most rainy areas of the tropics an average rainfall of 100 inches is usual. But where the monsoon winds blow there may be two to four times this much rain. The heaviest rains occur on the slopes of mountains toward the wind. Even when the regions all around are having their rainy season, the mountain slopes away from the wind may receive very little rain.

There are several deserts within the tropics. The best known of these is the Sahara. Africa extends so far north that the settling air of the horse latitudes comes down on its northern borders. This air has little opportunity to absorb water, for the land contains almost none. Then it starts its way southward, becoming part of the northeast trade wind. This wind constantly increases in temperature as it continues to the south and becomes relatively drier than before. The chief storms of the desert are wind and sandstorms.

There is another desert in South America west of the Andes. Much of this desert lies in Chile. It is caused by the drying winds blowing down the west slope of the Andes. As the winds pass up the Amazon valley and east side of the Andes they lose their water vapor in heavy rains. The Amazon valley contains one of the great, green jungles of the world. By the time the winds reach the top of the Andes they are greatly cooled, and have lost most of their water vapor. As they sweep down on the west side, they increase in temperature and become drying winds. The result is a long, narrow desert on the west coast of South America.

Can people live in the tropics? In general the farther people live from the equator within the tropics, the better are conditions for healthful, comfortable living. Along the equator conditions are very unfavorable, except on mountains. In the lowlands it is always hot, sticky, moist, and often wet. Ordinary metals rust. Clothing, leather, paper, and wood mold or mildew. There are many insects in the tropics. In many places large snakes are rather common. It is difficult to maintain a clearing in a real tropical jungle, for surrounding plants extend into it where they can obtain light. Heavy rains wash the fertility from the bare soil.

In spite of these unfavorable conditions, the tropics offer the best possible growing conditions for some kinds of plants. It would be highly desirable, in order to increase the world's food supply, to develop tropical regions now lying as waste lands. Almost no real study has been made for finding improved conditions for liv-

ing in the tropics. It may be possible eventually to work out a system of manufacturing small, completely air-conditioned houses which may be set up in the tropics. Then white people can live in fair comfort enough of the time to maintain their energy.

Along the edges of the tropics are some of the most productive regions of the world. Sugar, bananas, coconuts, and pineapples are foods we regularly obtain from these more moderate tropical regions. White people can live in the moderate portions of the tropics. Peoples of some other races are better adapted in general to a hot climate than are white people. Many people of these races find their best conditions for living along the edges of the tropics. If we define the tropics as including those regions with average yearly temperature above 68 degrees, part of our own southwest and the Hawaiian Islands are within the tropics.

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

The tropical climate zone includes those places which have an average yearly temperature of —1— degrees or above. Wet regions near the equator have —2— variation in temperature from day and night. They have —3— variation in temperature from season to season. Desert nights are likely to have a night temperature —4— daytime temperatures. Rainfall in the tropical wet zones averages around —5— inches per year. Rainfall may be two to four times this much in the —6— zones. A desert produced by a combination of horse latitudes and trade winds is the —7—. A large tropical desert on the side of the mountains away from the wind is in —8—. Best living conditions in the tropics are found along —9—.

3. What is polar climate?

The polar climate is the coldest of three main kinds of climate. The weather zones typical of the arctic and antarctic regions are sometimes called the frigid zones. They do not correspond exactly to the land enclosed in the two polar circles. The highest average temperature in these zones is below 50 degrees for the warmest summer months. This is the temperature required to grow grain crops and ordinary trees. So we can say that the frigid zones do not have the kinds of vegetation which we consider necessary for our ordinary food supplies.

How cold is the polar climate? Just as children living in our southern states can understand somewhat better the nature of the tropics, so can the children of the northern states under-

Richard E. Byrd

The polar ice caps are part of the old continental glacier. Few plants or animals can live on year-around snow and ice. This glacier is near the South Pole.

stand somewhat better the nature of polar climate. If you have ever been in a real cold wave accompanied by a blizzard which has lasted several days, you have an idea of late autumn conditions around the poles.

In January the lowest temperatures around the North Pole average less than 40 degrees below zero Fahrenheit. The coldest winter weather north of the equator is in Siberia, where the average temperature for January is about 49 degrees below zero. Other places are warmer than this, and the temperature gradually increases until it blends into the colder temperate zone temperatures.

It is likely that the average temperature around the South Pole is lower than that around the North Pole. The frigid zone around the South Pole is larger than that around the North Pole.

The summer temperatures of the polar zones are not very high. These regions receive more hours of summer sunshine than any other part of the earth. Much of its energy is lost because the rays are very slanting, and lose much of their heat in passing through the atmosphere. Even when they do strike the ground, some are reflected by the ice and snow, and some are absorbed as the ice melts. Even though summer is not very warm, the temperature difference between the warmest and the coldest day may be as much as 120 degrees.

Because of the slowness with which the warmth of spring overcomes the conditions of the long, cold winter, the fall season is warmer than the spring. There is not usually much difference between day and night temper-

Robinson Studio

In regions along the edges of the Arctic, a few people can live. The dog sled is still an important means of travel.

atures, if we think of day and night as making up a 24-hour period. In the summer it is light much of the night, and in winter it is dark much of the day. There is no good reason for much daily temperature change.

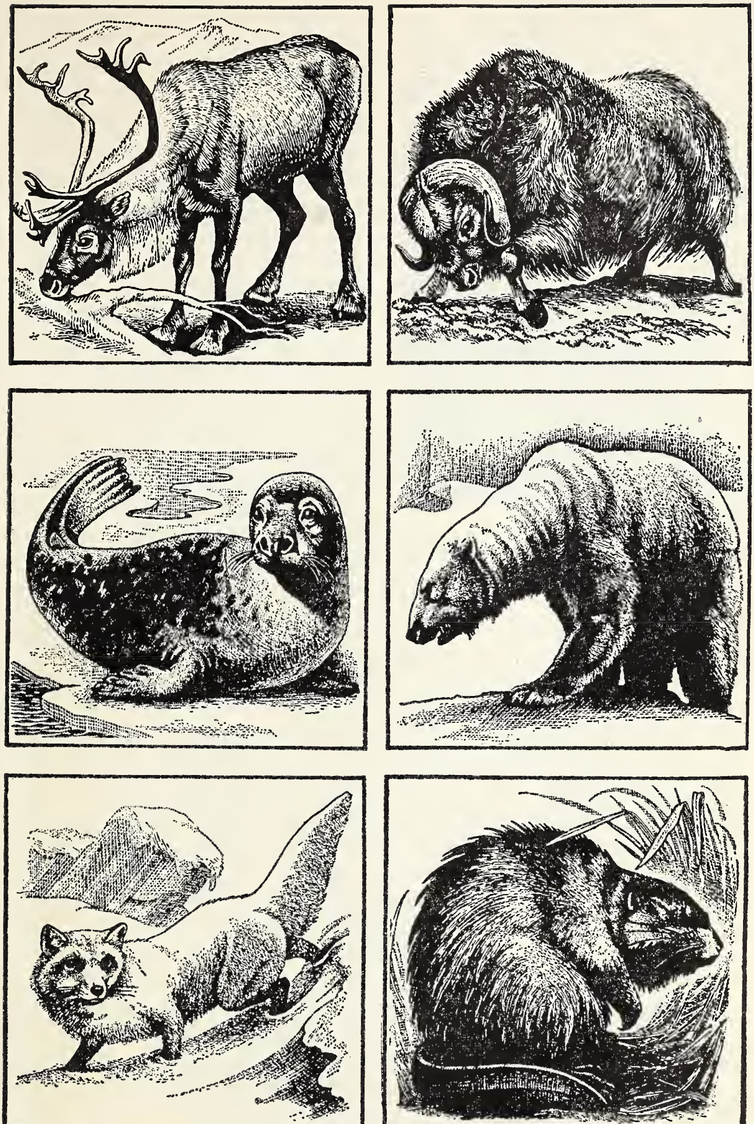
Is there much snow in the polar zones? You might think that because most of the polar zones are covered with ice and snow, that a great deal of snow must fall every year. This is not true, however. The winds which blow in the polar zones are so cold that they hold very little water vapor. And a wind will not begin to condense its water vapor until it is cooled. It is rather difficult to cool a wind that is already at a temperature 10 to 35 degrees below zero. There are not many mountains in the polar regions, and air masses rarely rise.

Nevertheless, light snows do fall, and occasionally there is a fairly heavy snowfall. The snow is fine and dry. Even on clear days ice crystals may form in the cold air. Little of the snow that falls is melted by summer heat.

The strong winds may make it seem that there is more snow falling than actually falls. The winds stir the light surface snow and mix it into the falling snow. You may perhaps have seen fine dry snow blowing into drifts where you live. You will remember that the air can be quite filled with snow, even when none is falling.

It probably never rains over much of the polar regions. Only along the edges does rain occur when a warm air mass escapes from the temperate zone.

Why are people interested in polar regions? If you will obtain



Rudolf Freund

The six most valuable Arctic animals are the woodland caribou, the musk ox, the hair seal, the polar bear, the Arctic fox, and the muskrat.

Robinson Studio

An Eskimo woman begins the skinning of a seal. For what are seals useful?

a globe and a string you may learn some interesting things. Stretch the string tightly, and find the shortest distance on the globe from San Francisco to London. Measure the distance from India to Chicago. These distances as measured by the string are called the great circle routes between the cities mentioned. Many important great circle routes pass over part of the north polar region.

We do not now fly great circle routes over the poles for several reasons. There are great distances without any people at all. In general people live only along the largest rivers and the ocean. It is not safe to fly over regions where nobody lives and where it is sometimes impossible to see.

It is difficult to establish air bases in the arctic zone. It is dark much of the year. During the long daylight season the light is very glaring, because of reflection from the snow. Ordinary materials sometimes freeze solid in the arctic cold. It has been necessary to warm gasoline engines of airplanes and tractors with blowtorches in order to start them. Grease on machines, unless it is specially selected for arctic use, becomes solid. Canned foods freeze if left unprotected. Nevertheless, some progress is being made in learning to live in extreme cold. Tractors which will run on the snow may replace dog teams. Warmer and lighter clothing and tents are being developed. Food is being improved.

Besides the need for air bases, another reason for wishing to explore the arctic is to discover minerals which may be found there. Coal and oil were formed long ago when the polar regions were almost tropical. Uranium, gold, and other scarce minerals may be fairly abundant.

Of course a few people have long lived in the warmer parts of the north polar zone. They live on fish, seal, and polar-bear flesh to a large degree.

Things to think about

Copy the following sentences in your notebook. Select the correct ending for each sentence.

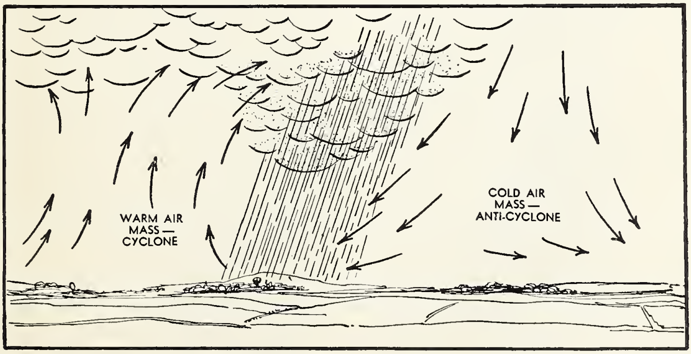
1. The polar regions are sometimes called the (*a*) torrid zones (*b*) blizzard zones (*c*) frigid zones.

2. The warmest summer month in the polar temperature zone has an average temperature (*a*) of 55 degrees (*b*) below 50 degrees (*c*) never above 32 degrees.
3. The coldest spot in the Northern Hemisphere is in (*a*) Alaska (*b*) Siberia (*c*) Greenland.
4. The zone which receives the longest hours of summer light is the (*a*) frigid zone (*b*) temperate zone (*c*) torrid zone.
5. The differences between day and night temperatures in the polar regions are (*a*) slight (*b*) at least 20 degrees (*c*) large.
6. Snowfall in the polar regions is (*a*) light (*b*) average (*c*) heavy.
7. The shortest line from one place to another on the earth follows the (*a*) meridians (*b*) globe (*c*) great circle.
8. In the polar regions people obtain most of their food from (*a*) mining (*b*) agriculture (*c*) the sea.

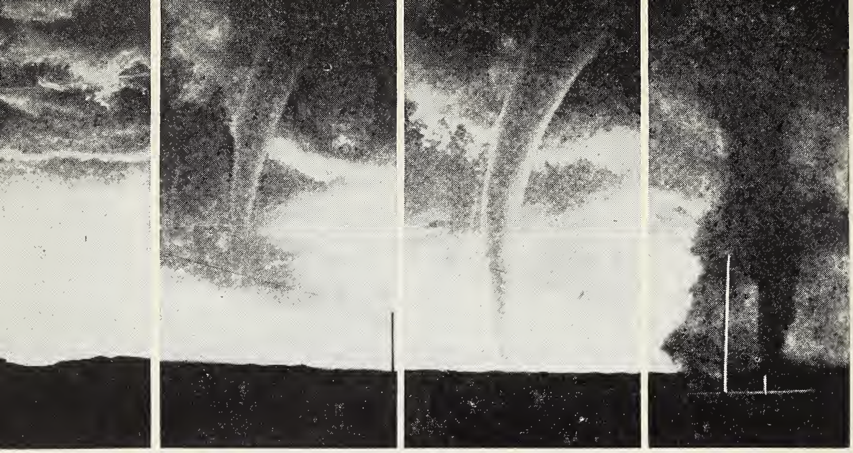
4. What is the temperate climate?

People in the temperate zones may almost be said to be living with borrowed weather. While we do have definite seasons and climates of our own, the winds which produce many of our storms come either from the polar zone or the tropics. We have already learned how air masses push their way into the temperate zones, producing some kinds of storms. We may define the temperate zone as the region of moderate temperatures and constantly shifting weather. You may not be inclined to believe that temperatures of 100 degrees above zero, or of 40 degrees below which occur in the United States are very temperate. Yet the average temperatures are neither very hot nor very cold.

What is the most common storm? The most common storm in the United States is the rainstorm or snowstorm. This storm extends over an area 500 to 1000 miles across. It moves from west to east, and crosses the United States in from four to eight days.



This diagram actually represents masses of air about 2000 miles in width and about seven miles high. Where the warm and cold air masses meet, rain is most likely to fall.



U. S. Weather Bureau

This remarkable series of photographs show (*from left to right*) the formation of a tornado cloud, the formation of the cone or funnel, the cone as it reaches the earth, and the cone filled with dust so that one cannot see the farmhouse which explodes as it is struck.

More storms come from the southwest than from directly west.

A storm area always has certain characteristics which may be observed or measured. The air pressure is low, and the humidity is high. The general direction of the movement of air in the storm area is toward the center. The mass of air tends to rise in the center of the storm area where the pressure is lowest. Because the air is rising, it is being cooled, and the cooling causes nimbus [nĭm′bŭs] clouds to form. Precipitation [falling of rain or snow] depends upon the humidity. The kind of precipitation is determined by the temperature.

The correct name of the large storms which cross the United States is *cyclone,* or *cyclonic storm.* This name must not be confused with *tornado,* which is the name of a small, violent wind which is accompanied by a funnel-shaped cloud. The names are often confused in newspaper stories.

The diagram (page 324) shows how air in a cyclone moves. The solid arrows leading to the area marked LOW show the direction of wind movement. Of course there is never a storm as perfectly formed as the one shown, because local conditions may cause the wind to turn aside. The diagram shows the average direction of wind around the average low-pressure area which is the center of a cyclone. The broken line shows the average direction of movement of the entire mass of air. Summer storms usually result from the presence of cyclones, while winter storms more often result from the meeting of cold and warm air masses.

What causes clear weather? You know that storms are fol-

lowed by clear weather. Clear weather occurs when a mass of cold air passes over a region. This mass of air behaves in a way exactly opposite that of a mass of warm air. It has a center of high pressure. The movement of wind is from the center outward, and it turns in the direction of the hands of the clock. The humidity is low, for the air is becoming warmer from contact with the earth and is therefore able to hold an increased amount of water vapor. These masses of cold air enter the United States from the northwest.

What are tornadoes? The most destructive wind that blows on the earth is the tornado. Not only does the wind in the funnel move at the teriffic velocity of 400 to 500 miles an hour, but it also blows with a twisting motion. The tornado starts as a dark, menacing cloud. From the cloud a funnel drops to the earth as the winds begin to whirl upward. The funnel becomes darkened by the sticks, dust, and other solids picked up by the wind. A tornado exerting its full force upon a building can wreck any ordinary house. Trees are twisted off like matchsticks. Buildings explode outward, and their roofs or walls are carried away by the wind. Iron spades may be driven through trees, and straws may be driven deep into boards. The funnel usually is not more than a few hundred feet in width and does not remain in contact with the earth for more than a mile or so.

No part of the United States is entirely free from tornadoes, but they almost never occur in the Pacific or Rocky Mountain states. They reach their greatest violence in the South and Middle West. The frequency of tornadoes is one of the many factors which determine the desirability or undesirability of the climate of a given region.

What causes thunderstorms? Thunderstorms form under conditions somewhat similar to conditions required for the formation of a tornado. In each case, the air lying upon the earth is much warmer than the surrounding upper air. Both are most likely to occur on a summer afternoon. Neither is likely to occur in the winter, except in the Gulf states.

The thunderstorm is much less destructive than the tornado. Damage may come from one of four sources. The lightning may do damage; the wind may break branches from trees; the rain may cause small floods; and the hail may damage crops, windows, or animals. The usual thunderstorm, however, is not dangerous. In fact, a person is in less danger standing in an open field in a thunderstorm than he is in crossing a city street through normal traffic.

Thunderstorms are caused by the uprushing mass of warm air as it breaks through the overlying cold air masses. The rapidly rising air is cooled so fast that water vapor condenses rapidly, producing the heavy downpours

of rain and hail. Hail results when raindrops are frozen by being tossed about in air currents in the upper parts of the cumulus [kū′mů·lŭs] clouds, or thunderclouds.

What are hurricanes? A hurricane is similar to a cyclone, except that it is smaller and moves with much higher speed. The speed of air movement in hurricanes at times approaches 100 miles an hour. Any wind with a speed of more than 75 miles an hour may be called a hurricane. Hurricanes are caused by a heavy, cold air mass forcing the warm air masses over the Gulf of Mexico to rise. In the center of the hurricane there is a calm, caused by the rising air. Hurricanes most often travel from the West Indies out into the Atlantic Ocean. Occasionally one may swing inland and strike the Gulf Coast anywhere from Texas eastward. Hurricanes are destructive because they may pile up huge waves or because they may destroy trees, buildings, and crops. One hurricane a few years ago caused much damage and loss of life in New England.

Dust storms. Dust storms are found in the dry western states and Great Plains areas. A dust storm appears as a coppery cloud, and the wind roars as it sweeps forward. The sky darkens as the dust covers everything. Visibility is reduced to 100 feet or less. In the worst dust storms, soil is carried away, leaving fields bare of crops. Houses, farm machines, wells, and trees are sometimes buried under dust by severe storms. The storm may destroy the value of the soil in cultivated fields by carrying away the best plant food.

Dust storms are caused by an area of high pressure sweeping down from the mountains over the dry plains. The wind not only dries the soil but carries away as much as is loose.

How do storms affect the climate? While the average weather determines the climate, the weather that occurs from day to day depends upon the frequency and violence of storms, and the amount of clear sunny weather that any region enjoys. The climate of most of the United States is one of rapid and rather considerable changes in temperature and other conditions of the air. Such a changeable and variable climate is said by some scientists to stimulate the energy of the people and to be a direct cause of the rapid development of the resources of this nation.

The production of food crops is determined almost as much by the kind of weather that occurs in the growing season as it is by the average conditions which make up the climate. The average daytime summer temperatures of the fruit-growing regions and the Corn Belt are similar. Yet the superior fruits of the Northwest depends upon sunny weather for ripening, while the rapid growth of corn in the Middle West depends in part upon the warmth of the nights. The

Right picture U. S. Forest Service

California trees vary greatly. The cypress (*left*) is of a variety found nowhere else in the world. The palm (*center*) is grown for decoration. The sequoias grow on mountain slopes.

amount of cloudiness and hours of warmth determine to some extent the kind of crops grown.

The amount of change from day to day determines how we shall prepare for each day in dressing and in planning work for enjoyment of life.

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

When the water falls as rain or snow, the general name of the process is —1—. In the center of a cyclone, or general storm, the pressure is —2—, the humidity is —3—, and —4— type clouds form. Winds whirl in —5— storms because of the —6— of the earth. The air pressure in an anticyclone is —7—, and the humidity is —8—. A violent, twisting wind which is very destructive is the —9—. Hail falls in connection with —10— storms. The wind velocity in a —11— is more than 75 miles an hour.

5. *What is the climate of the Western states?*

The United States is so large that it really has three climates instead of one. Each of the coastal regions has a climate different from that of the inland regions. The climates of the two coasts are much different from each other.

There are several conditions in the Pacific Coast and Mountain states that do not affect the climate in other parts of the country. First of all there is the nearness of the Pacific Ocean itself. The mountains of the West are much larger and higher than those of the South or East. Southern California in particular is influenced to some extent by the horse latitudes—the drying winds that move slowly along the edges of the tropics.

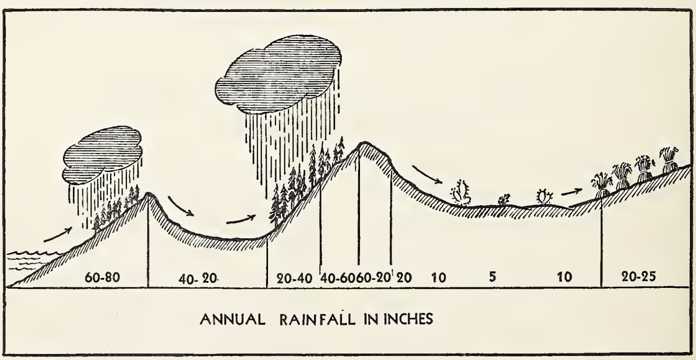
How do mountains influence rainfall? Across the Pacific Coast states the vapor-bearing winds blow from the Pacific Ocean. They sweep up the first mountain range which rises sharply from the coast. The coastal mountains extend north and south, almost at right angles to the direction of the wind. As you know, for every 330 feet that the air rises, it cools from one to 1.6 degrees F. When it has reached elevations of 6000 to 10,000 feet, the air is cooled more than 20 degrees. This much cooling reduces by one-half the capacity of the air to hold water vapor.

As a result of the sudden cooling of the moist ocean wind, the heaviest rain in the United States falls upon this first range of mountains, the Olympics. This region in northern Washington is one of the cloudiest in the United States.

As the wind sweeps down the first range of mountains, it comes to a wide, fertile valley. In this valley, Seattle, Tacoma, and Portland—the largest cities of the northern coast—are located. As the wind blows downhill, it is warmed. As a result, the rainfall in this valley is less than that of many eastern cities.

The wind passes on to the Cascade Mountains, higher and colder than the Olympics. Again the rainfall increases with the altitude as the wind drives up the mountain. Then the air, considerably dried, blows down the east side of the mountains, becoming warmer, and absorbing water from the land. As the wind blows downhill, the amount of rainfall decreases rapidly from 20 inches to less than 5 inches.

Gradually the elevation of the land increases, and as the wind approaches the Rockies, the rainfall likewise increases. The rainfall of the eastern part of Washington is about 20 inches. The rainfall of eastern Arizona is less than 20 inches.



In Washington the rainfall depends upon the altitude. Where the winds from the west blow up mountains, rainfall is heavy. Where the winds blow down the mountains, there is little rainfall.

Mountains are important factors in causing deserts. The most famous desert in the United States is Death Valley in southern California. Death Valley is the lowest land in the United States. It lies just to the east of the Sierra Nevada Mountains. A few miles to the west of Death Valley is Mount Whitney, one of the highest peaks in the United States. Some of the wind that comes from the lofty peak of Mount Whitney descends almost 15,000 feet into Death Valley, and in the process is warmed on the average about 50 degrees. It is little wonder that no rain falls in this region. There are larger deserts and, perhaps, more dangerous ones than Death Valley, but the name gives it a romantic appeal that other deserts lack.

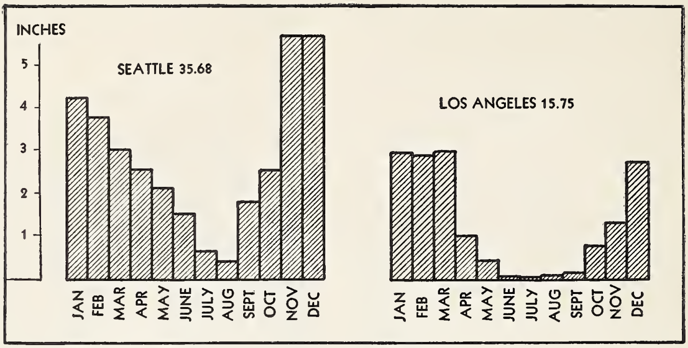
What effect does climate have upon vegetation? One of the sights every tourist looks for in the West is the big trees. There the trees attain great size because of the abundance of water on the west slopes of the mountains on which they grow. The redwoods of California are the largest trees in mass in the world. The tallest tree is a eucalyptus [ū′kȧ·lĭp′·tŭs] tree in Australia, but these trees are slender. Eucalyptus trees grow to amazing heights in California also. In Oregon and Washington the trees which grow on the rainy side of the mountains are the Douglas firs, the largest trees of their kind in the world. In these forests, ferns grow taller than a tall man.

In many of the western valleys splendid farms produce grains, fruits, vegetables, and dairy products.

Practically nothing of value to man grows in the deserts. Some cactus and grass is found in the deserts of the Southwest. The tall treelike cactus is rare. Most cacti are small, perhaps not more than a foot or two in height. The northern as well as the southern deserts contain sagebrush and greasewood—small gnarled plants with a very strong odor and tiny leaves. The smallness of the leaves of the desert plants reduces loss of water from them by evaporation.

Along the coast of southern California the climate is subtropical. Plants of this region are as strange to children of the rest of the country as are plants of a foreign land. It would seem strange to a child from the northern United States to see palm trees, orange trees, and pepper trees in his schoolyard. It would seem odd to have growing in his own yard such plants as the bamboo, Spanish bayonet, hibiscus, or oleanders. All these plants are common in southern California.

The traveler who first goes west experiences a feeling of loneliness because of the vastness of the places he visits. There are barren plains where for miles he sees only rugged rocks, low plants, and eternal dryness and glare. There also are towering mountain ranges, their lower hills and slopes clothed in dense forests and their peaks covered by glacial snow. From the regions



The Pacific Coast climate has a rainy winter season and a dry summer. The southern part of the coast has less rainfall than the northern. Would you prefer to visit Seattle in the summer or in the winter?

of heavy rainfall come streams which roar down in torrents over rocky river beds.

To a large extent, the West will always be as it is today, for there is not enough water to make large-scale irrigation possible. But where irrigation is possible, or where there is enough rainfall, the coast climate is one of the most pleasant climates one can imagine, for it is mild in winter and sunny in summer. The nights are always cool. This climate is excellent for the growing of fruits, grains, and crops requiring long hours of sunshine.

Why does most of the rain fall in the winter? The rainfall of the coast region is strongly affected by seasons. To a lesser extent the same is true of the Rocky Mountain region as far east as central Montana and Colorado.

The mountains are cool in the winter, but in the summer they are warmer than the ocean. Because of the high temperature of the land, the summer season is almost rainless.

Some temperatures above 120 degrees have been recorded in the deserts and in the central California farming region of the West. Because ocean air in summer is always cooler than the mountains and deserts, there is nothing to cool the wind to cause condensation. Thus there are many regions in these states where summer rain is almost unknown.

In winter the land is much colder than the ocean because land cools faster than water. In the winter months occur the heaviest rains. In general, as one goes south along the coast, the rainfall becomes lighter. The rainfall of inland towns depends almost entirely upon their altitude and upon whether they are situated upon the east or west slope of the mountains. There are few cities on east slopes of mountains except where there is irrigation.

The graphs on page 364 show the rainfall by months of two typical coast cities. The period of heaviest rainfall is from November to May. The rainfall of Seattle is typical of that of the northern coast cities. In an average year Los Angeles has almost no rain for four months in the summer. This condition is typical of much of the West.

The rainfall of southern California from Los Angeles southward is affected to some extent by the approach of the horse latitudes in summer, which add to the dryness of the summer season.

Because of the coolness of the air from the ocean, the cool nights, the freedom from rain, the West is one of the most pleasant regions in which to spend a summer vacation. The winters are rainy in parts of the northern coastal states. Most of the precipitation east of the Coast Range is in the form of snow. The winters of California are no rainier than those of other parts of the United States, for the total amount of water which falls in this region in a year is less than half that of the average Atlantic Coast or Middle Western city. The extreme Southwest has more winter sunshine than any other large area, and for that reason winter tourists are attracted to its resorts in large numbers.

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

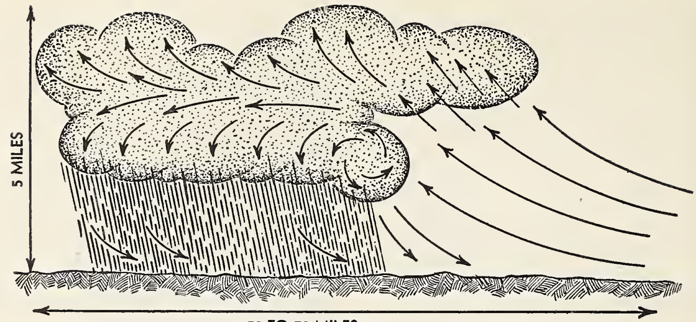
The two most important factors in the climate of the Pacific Coast are the nearness of the —1— and the elevation of its —2—. The side of a mountain toward the wind has heavy —3—. The valleys on the side of the mountain away from the wind are often —4—. The best known desert in the United States is —5—. The sequoias grow in the state of —6— where rainfall is fairly heavy. The Douglas firs are the big trees of the states of —7— and —8—. The heaviest rainfall of the Pacific Coast region comes in the —9— season. The mountain peaks are covered with —10—.

6. What is the climate of the Central states?

The central United States includes all the states on the east slope of the Rocky Mountains, the Great Plains states, and the North Central states. On the rainfall map the 40-inch rainfall line, which runs from Texas to Ohio, forms a rough eastern boundary of this region.

The average elevation of the central climatic zone is only moderately high, and the general slope of the land is away from the wind direction. That is, the wind blows downhill over most of this area. Because this region is far from the oceans, temperatures are often extreme.

The central zone gets little rain directly from either of the oceans. There are no elevations of great prominence to serve as local centers



The winds in a thundercloud are mixed and violent. The arrows show only the general direction of air movement and fail to show many whirls and eddies found in such clouds. Have you ever noticed the winds that blow out from the clouds just before the rain strikes?

of high precipitation. The chief reason that rain falls at all is that in all these states warm air masses are cooled enough to provide occasional rainstorms.

What is the climate of this zone? The east slope of the Rockies is dry, for the rainfall is less than 20 inches. At times there is enough rain in this region for agriculture, but usually there is not. Only in those years in which the rainfall is above average is there enough moisture for growing winter wheat. When the rainfall is even slightly below average, as it is half the time, the crops fail. In the region east of the 20-inch rainfall line crop failures are rare.

The average summer temperature is high. In the driest part of this region, the nights are often cool. Farther to the east and in the Great Lakes region, nights are often hot. In the Corn Belt states, from Iowa to Ohio, summer nights are frequently hot and humid.

In general, the winters are severe and dry. Snow covers the greater part of this region for months, not because much falls, but because winter temperatures rarely stay above freezing for many days at a time. The clear, dry cold of the Plains region is well known. The coldest part of the United States is in eastern Montana, part of North Dakota, and a corner of Minnesota.

In the eastern part of the central climatic zone, the temperatures are somewhat less severe than in the western part. The Great Lakes provide a slight moderating effect on the climate, and a greater amount of rainfall causes less rapid temperature changes.

The nights are hotter, and the days not generally quite so hot in the eastern part of this zone.

What is the effect of climate upon vegetation? In the drier, western part of the central climatic zone, the vegetation is scanty. Originally grasses grew

over almost all of this region. With the coming of the white man with his herds of cattle, his plows, and his prairie fires, much of the grass was killed and the ground left almost bare. In many places drying winds and heat have killed the vegetation, and the wind has carried away large amounts of topsoil.

In the region of the Great Lakes and the upper Mississippi Valley the summer vegetation is beautifully green. Hardwood trees are common. Streets are lined with large elm, locust, and basswood trees, whose branches almost meet above the street. Grass needs watering only part of the time, for rains often provide sufficient moisture throughout the summer.

The Corn Belt is part of the central climatic zone. Iowa, Illinois, and Indiana provide more than their share of corn. Wheat is grown along the 20-inch rainfall line as far south as Oklahoma. This belt is sometimes called "the nation's breadbasket."

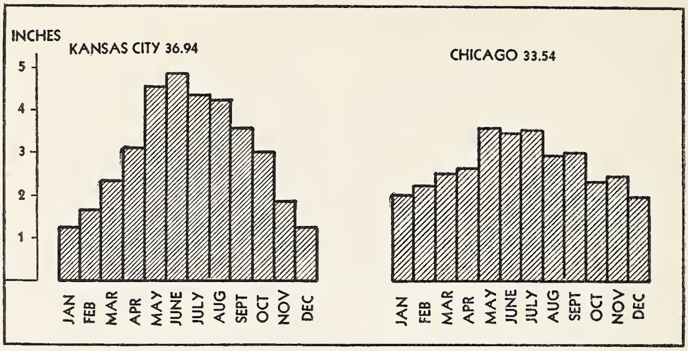
Why does most of the rain fall in summer? Fortunately for the farmers of the Middle West, the season of greatest rainfall is the growing season.

In the summer the great central part of the continent is considerably hotter than the coastal regions. Above it, a great mass of hot air creates a low-pressure area. The cooler masses of air above the Gulf, the Atlantic, and the Pacific force their way inland. More moisture comes from the Gulf and the Atlantic than from the Pacific, for there frequently is a high-pressure area above the cool Rocky Mountains which prevents movement of air from the west.

These cooler air masses carry with them large amounts of water vapor as they sweep inland from the Gulf and the Atlantic. The hot land warms these moist winds, and light air rises as cold air masses from the pole force it upward. As the hot air rises, it cools, and rain falls.

In the winter the opposite condition exists. The air pressure above the frozen land is high, and cold air flows off the continent toward the ocean. Warm winds have no way of moving against the higher pressure, and little water vapor is carried inland. About all the moisture that falls in the winter comes from water evaporated from the land.

The graphs show the rainfall of Kansas City and Chicago. Kansas City is near the dry portion of the central zone. Here the heaviest rainfall is in June, the same month in which Los Angeles, to the west, has little rainfall. Chicago has its heaviest rainfall from May to September, with less precipitation in the fall and winter months. If you compare these graphs with those of the Pacific Coast cities, you will notice that the two pairs of graphs are almost opposite each other in shape. St. Louis, the Twin Cities, and Milwaukee have their heaviest rain in the summer season, just as Kansas City and Chicago do.



The heaviest rainfall in the central United States comes in the summer months. How does this compare with the rainfall of the Pacific zone?

The winter precipitation in the central zone is almost entirely in the form of snow. Here winter rain is rare. The occasional snowstorm is likely to be short in duration, with a total snowfall considerably less than a foot in any one storm. The amounts of snow in this section are not comparable to those of the New England and Mountain states.

How are living conditions in the central zone? Michigan, Wisconsin, and Minnesota are favorite summer resort states for the people of the cities of the East, South, and Central states. The many lakes and fairly abundant summer rainfall make fishing attractive. The temperature is fairly low and the rainy periods of short duration.

The general health of the people of this zone has been found to be somewhat above the average of that of the people of the United States. The weather is often changeable, which seems to be good for the health, however inconvenient it may be for those who like to make plans for their activities without regard for weather. The second largest population center of the United States lies in this belt.

The winters are generally fairly long and quite severe. This adds to the cost of living by making necessary the use of heavier clothing and more fuel than is required in many other parts of the country. Indoor activities have been developed to a greater extent in this area than in many others, although for those who like winter sports there are some opportunities for skiing, skating, and ice boating.

Altogether, the central climate is one which contributes more to the prosperity of its people than to their comfort. Where there is enough rain, it is one of the world's best climates for agriculture of the sort which produces essential food supplies, such as pork, beef, corn, wheat, and dairy products.

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

The rainfall of the central climatic zone falls when an area of —1— passes by. The rainfall of the states on the east slope of the Rockies is less than —2— inches. The belt which bounds the central zone on the southeast is the —3— inch rainfall line. The most severe winter weather in the United States is in —4—. The most important crops grown in the central states are —5— and —6—. Most of the rain falls in the central zone in the —7— months. The central climatic zone is —8— for the health. The heaviest rainfall in Kansas City is in the month of —9—.

7. What is the climate of the Atlantic and Gulf states?

The climate of the Gulf and Atlantic states is much different in several ways from that of either of the zones already studied. The rainfall is more uniformly abundant, the temperatures are higher and less severe, and there is a difference in the distribution of rainfall throughout the year.

The most important factor in this climate zone is the Gulf of Mexico, which cuts deeply into the continent and provides a large area of warm water to supply the water vapor and to warm the air which passes over the southeastern states. The Atlantic Ocean also provides a tempering effect for some distance inland. There are ranges of low mountains which tend to increase the rainfall and to lower the temperature. The zone stretches over a great distance north and south, so that latitude causes marked differences in temperature and vegetation. The movement of air inland is caused almost entirely by the differences in air pressure of cyclones and anticyclones.

The inland boundary of this zone roughly follows the 40-inch rainfall line from Texas to Ohio and then northward to include New York. Along this line one type of climate blends into the other. There is no sharp boundary between the Atlantic and central zones.

What are the general climatic conditions in this zone? The things that this entire zone has in common are abundant rainfall and fairly moderate temperatures. In other respects it is necessary to describe the climate of the different regions separately. The climate of the Gulf Coast is semitropical, with long hot summers and very rarely any frost. The heat is tempered to some extent by the cooler breezes which blow from the Gulf.

Florida has perhaps the most even and warmest temperature of any place in the United States, because it is so nearly surrounded by water. The rainfall is exceptionally heavy in parts of Florida and all along the Gulf Coast.

The climate of North and

The New England fishing fleet is at anchor. The New England states were under ice in the last glacial age, and much of the land is stony and unfit for farming; so many New Englanders have other occupations than farming.

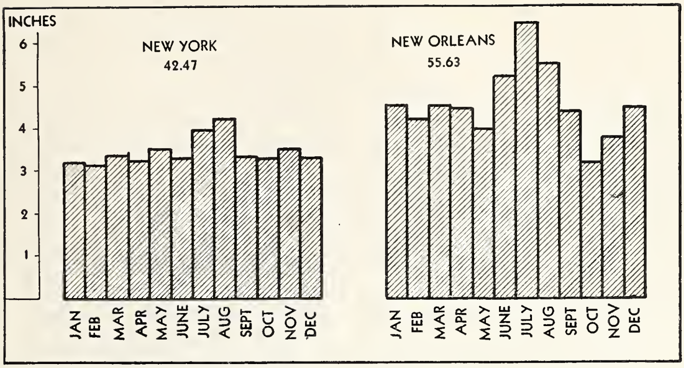
South Carolina and Virginia is warm, temperate, and pleasant in the lowlands, except in the occasional swamps along the coast. The mountainous regions have short, fairly cold winters, and are cool in the summer.

The winters of New York and Pennsylvania are cold and rather severe. Snow is abundant. Near the ocean the temperature is higher, and winters are less severe. Much of these two states is somewhat mountainous, so that the influence of altitude upon the climate is felt.

The New England states have cold, severe winters. The summers are generally cool and pleasant. The snowfall is generally fairly heavy.

What is the effect of climate upon vegetation? The most luxuriant vegetation of the United States is found along the Gulf Coast. This region not only has an abundance of rainfall, but also a long growing season. Coconut palm, mangrove, palmetto, and cypress trees may be found near the Gulf. On higher land long-leaved pine trees and live oaks grow. The flowering magnolia and rhododendron provide beautiful blossoms not commonly found in other parts of the United States.

Cotton, corn, sweet potatoes,



In the Gulf and Atlantic zones the rainfall is fairly uniform and abundant at all times of the year. The slight increase in late summer is caused by the sweep of air inland to the hot central zone.

peanuts, rice, bananas, tobacco, and citrus fruits are among the more important crops of this region. Dry weather and frost are alike unknown in most of this climatic zone. Irrigation is unheard of in this region.

The trees often are covered with moss which hangs almost to the ground. Of several varieties which are found, the best known is Florida or Spanish moss. Mosses grow luxuriantly only where there is abundant moisture to be taken from the air. The familiar fishpole canes grow in a thicket called a canebrake in parts of the South.

As one goes north the crops of the Middle Atlantic states gradually become more like those of the central states. Elms and maples replace other trees in the New England states.

Why does rain fall in all seasons? The path of the areas of low pressure which carry rain to the Atlantic zone goes from the southwest to the northeast. The air moves inward toward the centers of low pressure. Because of its comparatively short distance from abundant supplies of water vapor, the Atlantic zone is not dependent upon the Pacific Ocean or upon the land to the west for its supply of rainfall.

The rainfall is almost uniformly heavy at all times of the year. The graphs on this page show that the rainfall of New York is about like that of New Orleans in its distribution. At each city the rainfall is slightly heavier in July and August than in other months. There are no months of extreme dry weather in this zone. Boston, Philadelphia, and other Atlantic Coast cities have a distribution of rainfall like that of New York.

The reason for the inflow of vapor-bearing air can be seen by examination of the diagram on page 324. The arrows show how air moves inland from both the

Gulf and the Atlantic toward the area of low pressure. Because of the unusual conditions which make the Gulf practically a huge inland sea, the temperature of its water is considerably higher than the temperature of ocean water in general. Because of its higher temperature and because the winds which blow across the Gulf are warm, the quantity of water vapor in the air is large. The heaviest rain ever recorded in the United States for a 24-hour period fell in this region. There are two areas which have rainfall in excess of 60 inches.

In many parts of the South there are large swamps, those of Louisiana and Florida being the best known. Probably most of you, wherever you live, have heard of the Everglades of Florida.

What are the living conditions in the Atlantic and Gulf zones? The largest center of population in the United States lies in the North Atlantic states. The climate is invigorating and fairly healthful. The general conditions of life are similar to those of the central states. In both zones, severe winters make necessary well-built houses, heating plants, and use of expensive fuel in winter. Winter sports attract tourists, particularly in New York and the New England states.

Southern houses are not constructed to keep out cold. It is less expensive to build a home in the South than in the North, and less expensive to operate it. Clothing costs less, and vegetables and foodstuffs are more easily grown. The climate is not quite so healthful as that of the North, for malaria, intestinal parasites, and long periods of heat decrease resistance to some diseases.

In the South Atlantic and Gulf states the summers are in many places uncomfortably hot and humid. Probably the use of air conditioning in the future will make summers more comfortable, but at present there are many fairly large areas that are too hot for long hours of active work in summer. Where there is sufficient elevation to permit the growth of pine trees, the evenings are cool and the days more comfortable.

The favorite winter resort of the Atlantic Coast is Florida; although many other regions, such as New Orleans, Atlantic City, and the Gulf Coast attract many winter visitors. The sunshine, warm days, and such summer sports as fishing, swimming, boating, tennis, and golf attract people from the North who become tired of shut-in winter living.

Climate is the major factor in determining to what place the greatest flow of tourist traffic will go at a given time of year. It is becoming an increasingly popular vacation custom to enjoy Christmas in the South. If the standard of living increases to a marked extent, trailer, railroad, airplane, and bus travel will be stimulated by the desire of peo-

ple to take advantage of the differences of climate which are found in various parts of this great country.

Things to think about

Copy the following sentences in your notebook. Select the correct ending for each sentence.

1. The most important factor in the Atlantic-Gulf zone is nearness of the (*a*) Gulf (*b*) Atlantic (*c*) Appalachians.
2. The most even and warmest temperature in the United States is found in (*a*) Virginia (*b*) Florida (*c*) Texas.
3. The winters of the eastern mountains are (*a*) short and cold (*b*) long and cold (*c*) short and mild.
4. There is very rarely any snow in winter along the (*a*) Gulf (*b*) Mississippi River (*c*) Atlantic Coast.
5. The distribution of rain in the Atlantic-Gulf zone is (*a*) equal in all seasons (*b*) greatest in summer (*c*) greatest in winter.
6. Water which falls as rain in New York comes chiefly from the (*a*) Gulf (*b*) Atlantic (*c*) Pacific.
7. In this zone, winters are most severe in the (*a*) Virginia mountains (*b*) Gulf coastal plains (*c*) New England mountains.
8. Air moves inland carrying water vapor with it toward (*a*) high-pressure areas (*b*) low-pressure areas (*c*) mountains.
9. Winter sports are featured in (*a*) Florida (*b*) New York (*c*) North Carolina.
10. The heavy rainfall of the South sometimes produces (*a*) mosquitoes (*b*) swamps (*c*) cold weather.

A review of the chapter

The sun provides energy which causes the forces making up weather. Climate is the average weather of a region. The chief causes of differences in climate are latitude, altitude, nearness to large bodies of water, and direction of the wind. Temperature becomes about one degree lower for each 330 feet of altitude and each 62.5 miles of latitude. Rain falls where vapor-bearing air is cooled. Thus, the rainfall is heavy on the side of a mountain toward the wind. Rain falls in areas of low pressure, because there warm air is rising to cooler regions. High-pressure areas bring clear weather.

Tropical and frigid climatic conditions are generally more difficult or severe than those of the temperate zones. Yet man is able to adjust to some extent to these great extremes of temperature, winds, and precipitation found in the temperate zones. A variable climate seems to be an advantage in developing our civilization.

Several kinds of storms affect us. Tornadoes, thunderstorms, hurricanes, and dust storms are particularly destructive.

The climate of the Pacific Coast is influenced more by mountains and the Pacific Ocean than by latitude. The climate of the central states is extreme, because there is no water near. The movement of

air inland from the Gulf and the Atlantic toward areas of low pressure makes the Atlantic-Gulf climate milder than that of the central states. The rain of the Pacific Coast falls chiefly in winter, that of the central states chiefly in summer, and that of the Atlantic-Gulf states equally throughout the year.

Word list for study

Be sure that you can pronounce, spell, and use in a sentence every word in this list. Each of these words has been defined or explained and used in this chapter.

climate	latitude	isotherm
altitude	monsoon	great circle
temperate	cumulus	compressed
redwoods	graph	vapor

An exercise in thinking

Below are two groups of sentences. The first group contains principles, which are large general ideas. Each sentence in the second group contains an idea related in some way to one of the principles in the first group. Write the numbers from 1 to 32 on a piece of paper or in your notebook. Find the principle which best explains the idea in the second list. Then after the number on your paper write the letter before the related principle.

List of principles

A. The more nearly the sun's rays strike a surface at a right angle, the greater is the amount of energy received by the surface.

B. Rotation of the earth causes air movement.

C. The general direction of air movement is from cold to warm regions.

D. As warm air rises it expands and is cooled.

E. As cold air settles it is compressed and becomes warmer.

F. As air becomes warmer its ability to hold water vapor increases.

G. As air becomes cooler its ability to hold water vapor decreases, until a point is reached at which water vapor condenses.

H. Water holds more heat than does land.

List of related ideas

1. A barometer tends to rise where cool air is being warmed.
2. The winter climate of the Pacific Coast states is mild.
3. Latitude is the most important factor affecting climate.
4. If the world were uniform in temperature we would still have winds.
5. There are great deserts in the horse latitude belt.
6. Air cools rapidly in a thundercloud.
7. Air moves from the Gulf to the Central states in summer.
8. Terrific downpours of rain or

hail often accompany tornadoes.

9. Clouds often form around mountains covered with glaciers.
10. Clouds may disappear into the air as a cool air mass approaches.
11. Air blows from land to sea in winter.
12. A whirlwind rotates counterclockwise in the United States.
13. The polar regions are not very warm even when the sun shines 24 hours a day.
14. The temperature of the upper air is usually below zero.
15. Polar air masses bring clear weather in the United States.
16. The climate of the Middle West is extreme.
17. Air flows outward from the central states in winter.
18. Winds may blow because air has inertia.
19. The southern states are warmer than the northern states.
20. Air pressure inside a tornado funnel is low.
21. A tire is heated by pumping it up.
22. Rain falling from high clouds may evaporate before it strikes the earth.
23. The climate of the Gulf and Pacific States is not extreme.
24. The air above the polar regions contains almost no water vapor.
25. The desert becomes hot faster and cools faster than does moist farmland.
26. Fog often forms in low places at night.
27. Storms usually cross the United States from the west.
28. The land is cooled as a high pressure air mass moves over it.
29. The average temperature steadily decreases as one goes north in central North America.
30. Increasing air temperature 20 degrees reduces relative humidity by about half.
31. Winds blow from lakes to the land on summer days.
32. Warm air masses usually cool as they start to rotate and rise.

Some things to explain

1. Explain why changing your climate changes your way of living.
2. What happens to the heat given off when snow falls?
3. Why are the most pleasant places to live often of little value for farming?
4. Explain how weather changes affect your energy.
5. Name five things that make living more expensive in the North than in the South.
6. Is soil or climate the more important in making the Middle West the farm belt?

Some good books to read

Baer, M. E., *Rain or Shine*

Brown, V., *Amateur Naturalists Handbook*

Comstock, A. B., *Handbook of Nature Study*

Gaer, J., *Everybody's Weather*

Osborn, F., *Pacific Ocean*

Pickwell, G. B., *Weather*

Pickwell, G. B., *Deserts*

Stefansson, E. S. B., *Within the Circle*

World Book Encyclopedia

Ewing Galloway

UNIT SIX

LIVING THINGS AND MAN

On the worktable was a large flat box containing soil and some flowerpots. Susie Ann explained their use. She said, "One of the interesting hobbies of science is growing houseplants. I am going to show you how to pot a cutting. I have prepared the cutting by taking a small branch from a sedum. A sedum is a foliage plant. I put this cutting into a glass of water and left it for several days. It now has small roots on it. You will observe what I do as I explain."

She started working at the table. "The small piece of broken flowerpot I am putting in the bottom of the flowerpot covers the drainage hole. If I did not cover this opening in the bottom of the pot, soil would run from it. Also, the hole might become clogged by soil and roots so that the pot would not drain. Now I am filling the pot about two-thirds full of soil. This is a good, rich garden soil mixed with a little fine sand."

She poured water on the soil in the pot as she talked. "Watering the soil does two things. It causes the soil to settle, and it makes the soil provide better growing conditions for the cutting. Now observe that I hold the cutting just in the center of the pot while I place the soil around it. I do not exert much force in putting the soil around the plant. I do not want to break the delicate roots. I looked to see that the roots were spread before I started covering them. I am going to add soil and wet it down. There should be about an inch of space above the soil so that I can add water as needed.

"Putting a tumbler over a sedum cutting is not absolutely necessary. But when the room is quite dry, and the roots of the cutting are small, some plants need protection. A tumbler placed over the plant prevents evaporation while the roots are developing. The tumbler is removed when the plant seems to be well started."

CHAPTER

11

The Business of Being Alive

Being alive is a complex business. There are many problems which must be solved by any living thing. It must get water and food. It must keep warm. It must be able to produce and in some way bring up new individuals. If you like to imagine things, think of how you would solve these problems. How would a penguin keep its eggs warm enough to hatch on the ice near the south pole? How could a fish see its way so deep in the water that there is practically no light? How does an owl find food on really dark nights? Why does a sparrow have toes which fit around a branch? How did sand burs develop the little hooks which catch on your clothing? How does it happen that some insects look so much like their surroundings that they are almost invisible to our eyes?

If you do not know the answers to these questions, you should not be discouraged. Some of them cannot now be answered by any scientist with any certainty. But thinking about these problems does show, in many ways, how living things solve their problems.

It seems very confusing to try to recognize the many plants, insects, and birds which we see every day. But if each of these living neighbors had a different way of getting along, it would be still more confusing. Such, fortunately, is not the case.

It is useful to the beginning scientist to know that all living things have the same problems, and have certain common ways of solving them.

Some activities to do

1. If you started a project last year of labeling trees, flowers, or plants, continue the project and relearn the identification of common plants in your neighborhood. (See *Exploring Modern Science.*)

2. If you have an insect collection, add several specimens to it. If you do not have a collection, start one. You may be ready to specialize on one kind of insect, such as beetles or moths.

3. Make a collection of seeds and fruits showing the various ways in which seeds are scattered.

4. Examine spider webs to see what kinds of insects you find in them. Notice how the webs are constructed. Try to make a collection of photographs of spider webs.

5. Put two live fresh-water clams in an aquarium with about two inches of clean sand in the bottom. Put some water plants in the aquarium to provide oxygen. Provide a little fish food from time to time. Observe the movement of the animals.

6. Make a list of all the flying animals you see during one day.

7. Watch your dog walking and running, and see how many ways he has of using his feet at different times. Make a report in class.

8. Set up an aquarium [a tank for fish] containing a goldfish or minnow, one crayfish, one newt, one baby turtle, and several snails. You will need clean sand for the bottom and several water plants, also.

9. Obtain a showy flower and examine its parts under a magnifying glass. See if you can find undeveloped seeds in the ovary.

10. Observe dragonflies laying their eggs as they dip their bodies in the water, or find a grasshopper laying its eggs in dry, firm soil. Dig up the nest, and count the eggs.

11. Arrange for the class to visit a place where bees are kept. Learn from the beekeeper how the bees live.

12. Ant colonies, complete with a glass-sided nest, may be obtained from biological supply houses, or colonies of ants may be brought from out of doors into the classroom. Set up a colony and study it. Be careful that ants do not escape into the classroom.

U. S. Bureau of Biological Survey

The coyote is an animal which fits into its surroundings very well and is able to survive. Its color helps it to hide in dry, rocky country; it can run tirelessly and fast; and it is cunning and a good fighter.

13. In the late fall, after frosts have killed the hornets, collect a nest. With a pair of scissors cut off half the covering, and see how the nest is made up of a series of floors, each made up of cells.

Some subjects for reports

1. The ants which produce and store honey
2. Wild animals of the arctic regions
3. The snakes that live in your region
4. Turtles found in your region
5. Nesting places for birds in your region
6. Some strange adaptations of animals for getting food
7. Life at the sea bottom
8. Animals which give off light
9. Birds of prey and their value
10. Game laws and need for protecting animals

1. How do plants and animals stay alive?

Life itself is surely the most wonderful and the most interesting activity on earth. While it is difficult to define life, its characteristics are easily discovered if we compare some organism [ôr′găn·ĭz'm, any living thing], such as a robin or a tree, with some nonliving thing, such as a stone or a piece of iron.

How do living and nonliving things differ? Living organisms have many ways of fitting into their environments [ĕn·vī′rŭn·mĕnt, the entire surroundings of a living thing]. For example, the robin and the tree have the power of growth, while the stone and piece of iron do not have this power. In order to grow, living things are able to get and use food. Their tissues [tĭsh′ūs, a group of cells] are continually being destroyed and rebuilt as they move and do their work, and the waste products formed must be removed. While nonliving things may be changed by forces outside themselves, the products formed usually are left where the change occurred. Living things must transfer food to and waste materials from all parts of their bodies. We have already learned that both plants and animals must have air.

When living things have completed their activities, they die and become nonliving material. Yet life does not stop, for living things have power to reproduce others of their kind.

What conditions are necessary for life? All the necessities of life are obtained by living organisms from the surroundings in which they live. All forms of life must have many of the same things, but all do not live in the same kind of surroundings. To get food, water, and air, and to provide the conditions necessary for life, living things have developed certain adaptations. While some organisms are found in the cold polar regions and others live in warm tropical regions, each has become fitted to the conditions in which it lives. Thus different living things have different ways of doing the same things necessary for life.

What are the problems of all living things? When you consider the environments of an earthworm, of a weed on an ash heap, and of a fish, it may be difficult to see how such environments can provide each organism with food. Yet each gets enough to survive. You know that animals obtain their food by eating, and that plants must get their food in a different way. Some plants, which are green because of the presence of chemicals, make food from carbon dioxide and water. Other plants, which are not green, are unable to make food, but obtain it from other organisms. For almost every imaginable food material, there is some organism adapted to use it.

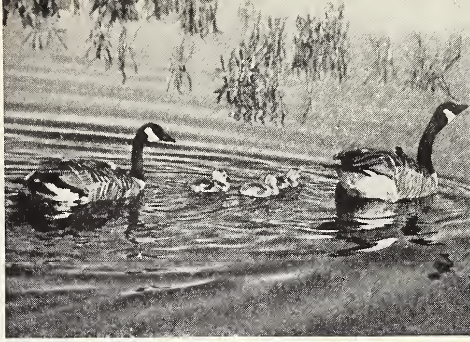
Practically every living thing, regardless of where it lives, must have air. Land animals live in air. Animals that live in the water must have air, but we know that they cannot breathe in the same way that land animals do. Plants as well as animals must have oxygen in order to live. There are a few bacteria that can live without taking in oxygen from the air. In fact, they cannot live in air. But these are exceptions to the general rule.

All living things contain large amounts of water which serves them in many important ways. Water is used by both plants and animals to carry foods to all tissues and to remove wastes. Water is also necessary for carrying on digestion and many other activities.

Many plants can live for some time without water, but they cannot grow. The small plants found in seeds may live for years without growing. When we plant seeds in the garden, we are really putting them where they can get water. Only those plants which are able to store water are found living in desert regions. Plants generally absorb water through their roots, although some of the very small ones may absorb it through any part of their surface.

Decay is caused by certain bacteria and other fungi. Because these small plants cannot grow without water, they cannot grow in dried foods.

Plants and animals do not just live—they must live in certain places. The environment must provide plants with a place for their roots, and animals with a home of some kind. In this living space they must find protection, carry on all the activities that keep them alive, and bring up their young. Almost all living organisms require protection against things which might kill them. Bacteria need protection against sunlight, plants need protection against certain animals, animals need protection against extreme cold, and so on.



U. S. Bureau of Biological Survey

Among the most interesting wild animals are the birds. These Canada geese swim in a lake which once was drained but which since has been restored for wildlife. A satisfactory home is essential for all living things.

How is life affected by temperature? Different living organisms can exist in widely different temperature conditions. The most favorable conditions for the majority, however, is between 40 degrees and 100 degrees Fahrenheit. Most life is killed by the temperature of boiling water [212 degrees Fahrenheit]. Yet there are a few plant forms found in hot springs where the water is nearly this temperature.

Mammals are hairy animals. During the late summer they may grow heavy coverings of hair, which are shed in the warm days of spring. This buffalo has part of his shaggy winter coat on his body.

Active life is stopped at temperatures below the freezing point of water [32 degrees Fahrenheit]. Water must be in the form of a liquid to carry food and wastes in the body. If the liquid is changed to solid ice, the tissues of either plants or animals are unable to use it. However, the plants do not necessarily die when the water in the soil changes to ice, but simply stop growing. There must be some period during the year when the ice melts if life is to be resumed.

Plants and animals are adapted in many ways for meeting the changing conditions of the seasons. A few animals, such as many birds and the Monarch butterflies, can migrate to a region suited to their needs as seasons change.

A large number of plants and animals survive winter in an inactive stage. Many insects lay eggs that can withstand freezing, and which hatch only when the warmth and moisture of spring start growth of the young within the egg. Many plants produce seeds which contain small, inactive plants that grow only when stimulated by warmth and moisture. Such fungous plants as toadstools, molds, and bacteria and the small water-scum plants, the algae [ăl′jē], may form spores that can resist both freezing and drying. Thus the species can survive either winter weather or long dry periods. The adults of this group of organisms usually die when seasons change.

Many other living things reduce the rate of their activities and enter a resting stage when

seasonal changes make conditions unsuited to growth. You are familiar with the shedding of leaves by many varieties of trees. The evergreen trees keep their leaves but do not make food or grow in freezing weather. Potatoes, lilies, and ferns maintain living buds underground in special parts, and these buds grow when spring comes.

The insects belong to the animal group. Many insects hide away in protected places and barely remain alive when it is cold. Snakes often spend the winter in some kind of den. Many rodents hibernate in burrows. During hibernation their body temperatures drop. They barely breathe, and they seem to be dead or in deep sleep. They may awaken enough to eat food stored in the burrow, but immediately return to their resting stage until warm weather returns. Frogs and some turtles bury themselves in the mud of ponds where the water does not freeze. Here they remain inactive until warmth revives them.

Many animals remain active all winter. They may grow heavy coats of fur, or change color, or otherwise fit themselves for the changed conditions of winter. In spite of their adaptations, many more animals die in winter than in summer.

There are many life activities which generally are carried on in spring or summer. Producing young and rapid growth require favorable conditions. Birds usually shed their feathers in the fall. Most animals shed their coats of winter hair in the spring and during the summer begin the growth of heavy coats needed for winter.

Ward's Natural Science Establishment, Inc.

When a frog sings or croaks, he inflates his throat with air. Animal songs either attract other animals or warn them to stay away.

What are life functions? All the activities of living things are called life functions. You are already familiar with some of them —food getting, reproduction, breathing, movement, growth. There are also ways in which animals and plants protect themselves, bring up their young, and live together. If the life functions of a living organism are properly operating, then we say that it is adapted to its environment. If not, either it or its young will die.

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

Growth is possible only among —1— things. Fishes must use the —2— which is dissolved in water.

Those things which an animal has or does in order to fit into its —3— is an adaptation. Bacteria which cause decay can be stopped from growing if they lack —4—. An organism adapts itself by performing certain essential —5—. For example, —6—, as well as animals, must get food, which is the source of —7— for all activity, and provides material for —8—. Undeveloped insects in eggs and undeveloped plants in seeds often remain —9— in winter. During —10— some large animals remain alive but inactive.

2. How do some organisms get food?

You will readily agree that no other life function seems more important than food-getting. Food is essential for providing energy for all activities, as well as for providing for growth and repair of the organisms.

How do plants get food? Plants do not actually get food, for the fact is that most plants make their food. Only the plants (the fungi) of which bacteria, yeasts, molds, and mushrooms are examples actually get food from sources outside themselves.

Most plants contain a green substance called chlorophyll [klō′rō·fĭl] which has the power of making food. The materials out of which the plant makes food are obtained from the soil and the air. Water and minerals are taken by the roots from the soil. Carbon dioxide is taken by the leaves from the air. The chlorophyll in the leaf first makes sugar from water and carbon dioxide. Chlorophyll alone cannot make food, but must obtain energy from sunlight. The plant works more during the day than at night. After sugar is made, the plant combines it with minerals to make other kinds of food (proteins). Some parts of this food are used immediately by the plant. Other parts of the food are stored in various parts of the plant for its own future use. Celery plants store food in their stems. Beets and turnips store food in roots; cabbages and onions store it in leaves. Corn, beans, and apples store food in seeds and fruit.

This spider web covered with dew is a trap which is the spider's means of providing a food supply.

The simplest green plants, the algae, live in water or moist places and take the minerals and other materials they need directly from water. They often grow so thickly in pond water that they give it a greenish appearance. Since many algae consist of only one cell, the individual plants may be nearly or quite invisible to the unaided eye, but they

The tongue of a frog or toad is used to catch flying insects. It moves with amazing speed. The advantage of having the tongue fastened at the front of the mouth is clearly seen.

carry on the same life functions as do larger plants.

The fungi take their food from other plants and animals—some from living organisms, others from dead organisms.

How do the large animals get their food? All animals depend either directly or indirectly upon green plants for their food supply. Many animals live entirely upon plant foods. Cows, horses, deer, sheep, and goats live upon grass and grain. Many other animals eat the grass-eating animals or other smaller meat-eating animals. Familiar meat-eating animals are dogs, tigers, and bears.

The adaptations of grass-eating and meat-eating animals are greatly different. The grass eaters have broad, blunt teeth for grinding their food. Their digestive organs are large, in order to hold a large enough supply of the low-energy food that they must depend upon. One large group of animals, including cows and deer, chew a cud—that is, food eaten while grazing is returned to the mouth for further chewing when the animal can lie down in a safe place. Grass eaters are better equipped for running than for fighting.

The meat eaters are fierce. The same teeth and claws they depend upon to catch and kill their food are useful for defense. Because the meat eaters eat a food rich in energy, they have smaller digestive organs. They eat their prey where they kill it, and may lie down in the open to sleep afterward, secure in the knowledge that they can take care of themselves. Most meat eaters are poor long-distance runners.

How do animals trap their food? Certain animals are trap builders. The garden spider builds a wheel-shaped web, which is suspended by a rough framework woven on twigs. The center is first woven, and from it the spokes spread to the rim. On the spokes a spiral [spī′răl, a circular line winding outward] is woven around and around. The threads of the spiral are sticky, while the other threads are not. The spider walks on the threads which are not sticky, but an insect falling or flying into the web becomes entangled in the sticky

threads. Then the spider rushes forth from the little tent which she has built at the side of the web and quickly spins a ribbon around the insect. Using her legs, the spider turns the insect over and over until it is hopelessly bound up. The spider eats her victim by sucking the juices from its body.

Another animal, the caddis worm or water sprite, builds a net in the running water in which it lives. This insect lives in a small case made of mud and sand held together by silken threads. Near its home it makes a trap shaped like a funnel [a cone-shaped tube], with the larger end pointing upstream. Across the lower end is stretched a net which lets the water run through, but which catches small particles of food carried by the stream.

The young ant lion or doodlebug lives in the sand. It digs out a funnel-shaped trap about an inch deep and an inch across in the loose sand. Then it lies in wait at the bottom of its pit. When a crawling insect, such as an ant, falls into the trap, it tries to climb out. By means of its flat head, the ant lion shovels a shower of loose sand upon the ant, causing it to slip back into the trap. The ant lion then seizes it and drinks its blood.

What animals raise their own food? Certain aphids [ā′fĭdz, plant lice] give off honeydew from their bodies as they suck juices from the plants on which they live. Honeydew contains a sugar and is a good food. Ants care for these aphids to obtain the honeydew.

Other types of ants clear large spaces, often several feet across, around the opening of the tunnel in which they live. On this clear space they raise a plant called ant rice and cut down all other plants. They harvest the ripe seed, which they clean and store in their tunnels for food.

How do toads catch insects? The toad catches its food, which consists chiefly of insects, with its tongue. The tongue is fastened at the front of the mouth and is free at the back. The free end is covered with a sticky substance and can fold around an object very quickly. The toad darts out its tongue with great rapidity at some moving insect which is caught on its sticky tip. During the day the toad remains in some sheltered spot, watchful for enemies, but not feeding. At dusk it goes out in search of food. Sometimes it may be found under a street light snapping up the insects which have been attracted by the light. Frogs catch their food in a similar way.

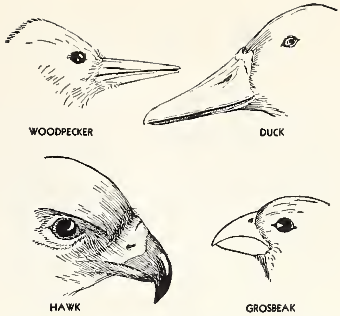
How do birds get their food? The most common food of songbirds is insects. Wherever insects are found, there are birds with bills fitted for catching them. It would seem that an apple worm had selected a perfectly safe spot for spending the winter when it hides its cocoon [kŏ·kōōn′, a protective case] in the cracks of the bark of a tree. But even there it is not safe from the attack of the

woodpecker. With their strong, chisel-like bills woodpeckers drill holes through the bark, and with their long, hooklike tongues they spear out the insects. Warblers and vireos have slender bills with which they pick insects from the leaves. The flicker uses its long bill to dig for ants in the ground.

The chimney swifts and the swallows get their food in the air. With mouths wide open like nets, they catch insects as they fly.

Sparrows have heavy bills used for crushing weed seeds, which may be taken from the ground or from the stalks of the plant. The hummingbird has a long, slender bill with which it sucks the nectar from flowers.

Some birds get their food from the water. Ducks fill their mouths with water plants and insects; and then as the bill is closed, the water leaks out while the food is left behind. This bill acts like a strainer. The kingfisher catches its food from water, which it watches from some convenient perch. When it spies a fish, it hovers for a moment above the water and then dives down, reappearing with the fish in its bill.



Each kind of bird has a beak best adapted for one particular kind of food. No bird has a beak fitted for using all possible types of food. Is a duck's beak useful for fighting?

Another bird that feeds on fish is the osprey or fish hawk. It searches from great heights over mountain streams and dives into the water when it sees a fish. After the fish is caught, it is killed and carefully cleaned before it is eaten. The osprey will not eat anything that has been dead long.

Hawks and owls have hooked bills with which they catch and tear apart mice and other rodents [the gnawing animals]. The hawks work by day and the owls by night.

Things to think about

Match the following subjects and predicates. Copy the sentences in your notebook.

Subjects

1. Hummingbirds
2. Woodpeckers
3. Hawks
4. Toads
5. Sparrows
6. Some spiders
7. The ant lion
8. Some ants
9. The osprey
10. Ducks' bills

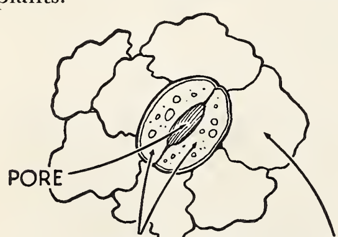
Predicates

A. catch insects with their tongues.
B. eats only freshly killed meat.
C. are adapted for straining.
D. catches insects in traps.
E. get nectar from flowers.
F. raise their own plant food.
G. catch their food in webs.
H. have bills for crushing seeds.
I. have bills adapted for drilling
J. have hooked bills.

3. How do plants and animals get air?

All living things, except a few kinds of bacteria, need air. As you know, air is not a simple gas. Various kinds of living things require different parts of the air. Only plants need carbon dioxide, but all living things need oxygen from some source.

How do simple plants and animals get air? The simplest animals, like the simplest plants, consist of only one cell. Most one-celled plants and animals live in water, and they absorb the air they need from the water in which it is dissolved. Plants absorb and use both carbon dioxide and oxygen, while the simple animals absorb and use only oxygen. When the sun shines on them and green plants give off more oxygen than they use, they are making food. As a result, the presence of plants in water improves the water for animals. Similarly, animals give off carbon dioxide, which is used by the plants.

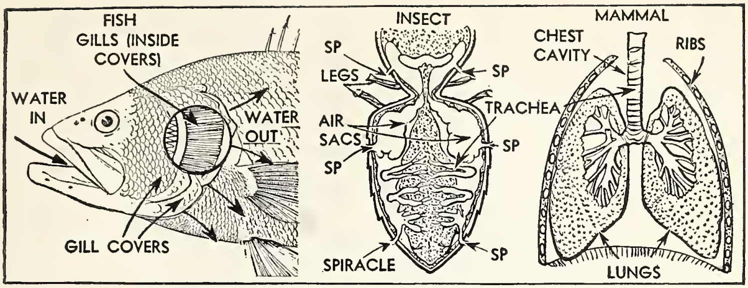


Air is taken into the leaf through pores called stomates. Each is guarded by two bean-shaped cells, called guard cells.

What plants use nitrogen from the air? Nitrogen is not used for the usual purposes of breathing, but when taken in by green plants it becomes a part of their protein food. Yet green plants cannot take nitrogen from the air. They must get it from the soil. Only certain bacteria which live in the soil can use air nitrogen. Some of these bacteria live on the roots of clovers, beans, and peas, from which they take their food. Other nitrogen-fixing bacteria live upon dead material in the soil. When these bacteria die, they add nitrogen to the soil.

How do seed plants get air? Seed plants have no means of breathing, yet they take in carbon dioxide from the air in amounts sufficient to make food for growth and future use. When you consider that there are only 3 parts carbon dioxide in 10,000 parts air, this is rather remarkable.

The seed plants usually take air in through their leaves, which are equipped with special openings for that purpose. If you peel off the thin skin from the lower side of a leaf and examine it under a microscope, you will see small openings, each between two bean-shaped cells. These cells guard the opening, and may close it if the leaf is losing too much water on a dry day. The opening through which a leaf takes in air is called a stomate



The fish can absorb oxygen from water through its finger-like pink gills. Insects and mammals (the hairy animals) are air breathers and take air into their bodies through special organs.

[stō′māt]. Most of the stomates are located on the lower leaf surface, where they are better protected from being clogged with dust than they would be on the upper surface. Desert plants have stomates on their stems.

Can animals absorb air through their skins? All larger animals have the same problem —how to get enough oxygen into the interior of their bodies without drying the body and without exposing it to harm. The smaller animals have an easier problem than do the larger ones, both because they use less air and because their bodies have a larger surface in proportion to their weights.

An earthworm takes in air entirely through its moist skin. Since the earthworm is rather a slow-moving animal, it does not use much oxygen. It lives underground in moist soil, from which it comes to the surface only at night or during rainy or damp weather. Air is absorbed much more rapidly through moist skin than through dry skin.

Frogs and their relatives the salamanders obtain a large portion of their air supply through their skins. Many other animals obtain a small portion of their air through their skins.

What animals have gills? In order to get a supply of oxygen into the blood stream, animals which live in water have gills. Gills are composed of thin-skinned tissues through which many fine blood vessels flow. The air dissolved in water comes into contact with the skin of the gill tissue, and passes into the blood stream. At the same time, the carbon dioxide given off in breathing passes out of the blood through the gills into the water.

Many animals have gills. As you know, the gills of fish are located on the sides of their heads, and water passes over them from the mouth. The gills of tadpoles are located on the head also, but the gills at first are outside the body where they branch like fingers to expose more surface to the water. Crawfish and lobsters have fine,

feather-like gills beneath the shell in the middle part of the body. The gills of the oyster family are inside their shells and consist of leaflike tissues. To provide fresh water for carrying oxygen to the gills, the oysters and clams have one tube through which they pump water into the body and another tube through which it flows out. The stream of water carries food as well as air to the oyster.

What animals get air through tubes? Gills are not practical for animals which live in the air instead of in water. One way of providing air to the bodies of such animals is by means of tubes which carry air to the various organs where it is needed.

The insects breathe through tubes. If you catch a grasshopper and look at it closely through a magnifying glass, you can see the openings of the tubes along its sides. These openings are called spiracles [spī′rȧ·k'lz]. From the spiracles there are tubes called tracheae [trā′kė·ē] which pass through the insect's body in a ladder-like pattern. The blood of insects is not used to carry air. Many insects have air sacs [saclike tissues] along these tubes which increase the surface through which air can be absorbed, and which make the insect light in weight and increase its ability to fly.

The young wormlike larvae [lär′vē] of insects also breathe through tubes and not through the skins as true worms do. Young mosquitoes, which are called wigglers and live in water, have long tubes which project to the surface of the water as they hang head down beneath the surface. Because mosquito larvae breathe in this manner, it is easy to kill them by putting oil on the water where they live. This clogs their breathing tubes and suffocates them.

How are lungs used for breathing? Such familiar animals as snakes, frogs, birds, cows, turtles, and whales breathe by use of lungs. For large animals lungs have advantages which are quite apparent. They are inside the body, where the delicate tissues are kept moist and protected from harm. They also provide an amazingly large surface for taking in air, because they consist of thousands of branching tubes and sacs. In the tissues making up each of the sacs there are tiny blood vessels which absorb oxygen from the lungs to be carried to all parts of the body. Lungs also give off waste gases from the blood.

Two kinds of animals, the birds and the common animals (mammals), have warm blood. In order to keep warm they require a large supply of oxygen to use up the food needed to give them energy. It is in these two groups of animals that lungs are most highly developed.

The whale, although it lives in water, breathes by means of lungs. It is a member of the same large group of ainmals to which cows and cats belong—the mammals, which feed their young on

milk. The whale comes to the surface to get air, usually at periods 5 to 10 minutes apart. It can stay under water for a half hour or an hour, but would drown if it did not come to the surface after that time passed. When a whale breathes out, it forces a column of warm, moist air into the air. The condensed water vapor is sometimes visible. This is blowing.

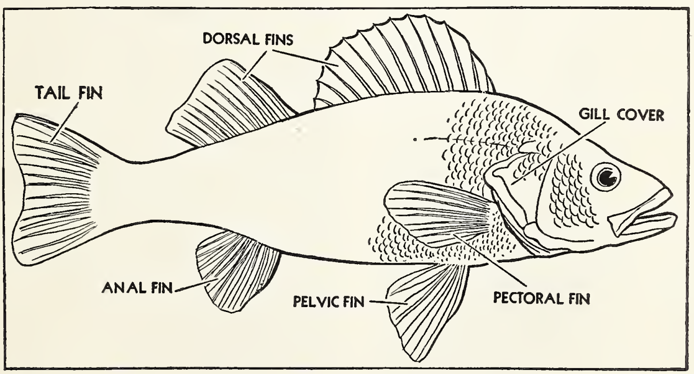
Things to think about

Copy the following sentences in your notebook. Select the correct ending for each sentence.

1. Green plants need carbon dioxide to (*a*) keep warm (*b*) make food (*c*) use food.
2. Animals need oxygen to (*a*) keep warm (*b*) make food (*c*) use food.
3. Air passes best through skin which is (*a*) moist (*b*) warm (*c*) dry.
4. Oysters, crayfish, and tadpoles breathe by means of (*a*) gills (*b*) lungs (*c*) trachea.
5. Warm-blooded animals breathe by means of (*a*) gills (*b*) lungs (*c*) trachea.
6. The only organisms which use nitrogen from the air are (*a*) algae (*b*) bacteria (*c*) one-celled animals.
7. The young mosquito breathes like (*a*) an insect (*b*) a tadpole (*c*) a worm.
8. The whale is a (*a*) fish (*b*) gill breather (*c*) mammal.
9. An animal that breathes through both its skin and its lungs is (*a*) a bird (*b*) an earthworm (*c*) a frog.

4. How do plants and animals move?

Living organisms move in order to find more favorable living conditions. Animals may move to escape from enemies, to find food, or to obtain greater comfort. Plants may move to obtain better exposure to light. There are really two types of mo-



The fins of a fish are used for movement and for balancing. The tail is the strongest of the organs of motion and provides energy for the greater part of the fish's forward movement.

tion. One type, called locomotion [lō′kȯ·mō′shŭn], is movement of the entire organism from one place to another, such as running or flying. The other type is movement of some part of the organism, such as the closing of a flower at night. Most animals have both kinds of movement, but plants generally have only the latter.

Some organisms are moved by forces outside themselves. Ocean currents, wind, and streams carry some organisms to new places. Young spiders spin webs which they use as parachutes to float in the wind.

How do plants move? Plants have only simple movements. To reach water carrying mineral food, a plant can cause its roots to grow in a certain direction. As a plant grows in height, some of its parts move to a new position. When buds unfold, they move. Leaves turn toward the light, as is shown if a house plant is left for some time before a window. All leaves tend to grow toward the same side. Leaves are especially sensitive to light when they are first opening in the spring. Some leaves, like clover, may close at night and open in the morning. Leaves of corn roll up when the air is dry and they are losing water at too great a rate.

How do one-celled organisms move? A drop of pond water under the microscope reveals great activity. Some of the one-celled animals move by whiplike movements of tiny, hairlike projections. Others tumble along, end over end. Still others slowly flow along, or slide through the water.

How do some other animals move? Only animals which have legs can walk. Since the only means of locomotion which the four-legged animals have are walking, running, and jumping, these adaptions are important to them, and they do these things well. Some animals, such as horses, may lift the feet in a variety of ways. In trotting, a horse lifts one front leg and the opposite hind leg at the same time; in pacing, both legs on the same side are lifted at one time. A dog can run on three feet if one foot is cold or injured.

The meat-eating animals have special adaptions for walking quietly. Grass-eating animals are well adapted for running on hard ground because of their hoofs.

Birds generally do not walk or run well, although a few, such as the road-runner of the Southwest, the ostrich, and the ring-necked pheasant, can outrun many dogs. The robin runs awkwardly and stops suddenly. Ducks waddle along with their bodies off balance. The crow and blackbird walk along slowly.

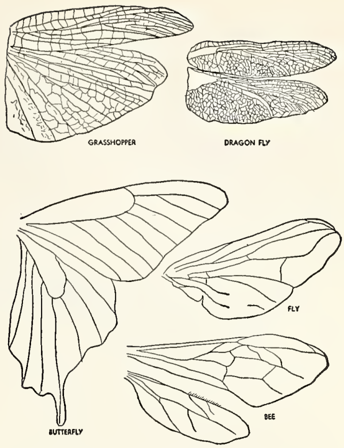
Insects can walk fairly well on their six legs. Some of the world's best jumpers are insects. The grasshopper makes astonishing leaps by use of its two large hind legs. A flea uses its six legs in jumping great distances. If a man could jump in proportion to his size as well as a flea, he could make a high jump of 450 feet and a broad jump of 700 feet.

There are many crawlers—earthworms, snails, and insect larvae. One of the most interesting is the earthworm. It moves by contracting two sets of muscles. One set of muscles running lengthwise can be tightened to make the worm short and fat. The other set running around the body contracts to make it long and thin. To keep its body from slipping, the earthworm has many tiny, stiff hairs on its underside. To move forward, they are pointed backward, for the body cannot slip back against the pressure of the hairs.

Snails move along by rippling the muscles on the undersides of their bodies. Land snails make a moist, smooth road of slime [a slippery fluid] for themselves as they travel. Insect larvae may inch along or crawl in other ways.

How do animals swim? Each kind of water animal has its own special adaptions for swimming. A fish has a streamlined body which reduces resistance to the water, and a strong tail fin useful for pushing itself forward. The other fins are used by a fish to keep its balance, and to prevent the body from slipping backward when the tail fin is moved. The scales also overlap in such a way as to reduce the tendency to move backward. The fish controls its weight in water by means of an air bladder, which may be regulated in the amount of air it holds.

Crayfish walk forward along the bottom of the lake, but can swim backward rapidly by a single stroke of the tail.



Most insects have four wings. The forewing of the grasshopper is used for protection. All the other wings in these drawings are used for flight.

Ducks and related birds swim on top of the water because their oiled feathers keep them afloat. If a duck's feathers are wet, it sinks up to its neck in water. The webbed feet are near the rear of the body. On the swimming stroke, the webbed toes are spread. When the feet are brought back for another stroke, the webs fold and offer little resistance to water.

How do animals fly? Birds are common flying animals. Both the bones and feathers of birds are strong and light. The bones of some birds weigh no more than the feathers. As birds fly, they hold their bodies at an angle like a kite in flight. The wings are used to provide the forward motion by striking forward and

downward. On the return stroke, the wing feathers turn slightly in their sockets to allow the air to pass through without resistance. Some birds can soar, using air currents to lift them by air pressure against their outspread wings. Birds are able to make long flights in their spring and autumn migrations.

Most insects have wings. The flies and mosquitoes have two wings. Beetles and grasshoppers have four wings, but use only the rear pair for pushing themselves through the air in flight. The front wings are thick and heavy, and are used for protection. The flight wings fold under the front pair when at rest. Butterflies, moths, dragonflies, bees, and wasps use all four wings in flying. The two wings on one side are held close together as though they were one wing. The dragonfly is one of the best fliers; one kind of beetle is one of the fastest fliers among living things.

Although the bat really flies, its wings consist only of a web of fine skin stretched between the very long fingers of the forelegs, and extending to the hind legs. Bats are very clever at turning and twisting in the air, although they do not fly rapidly.

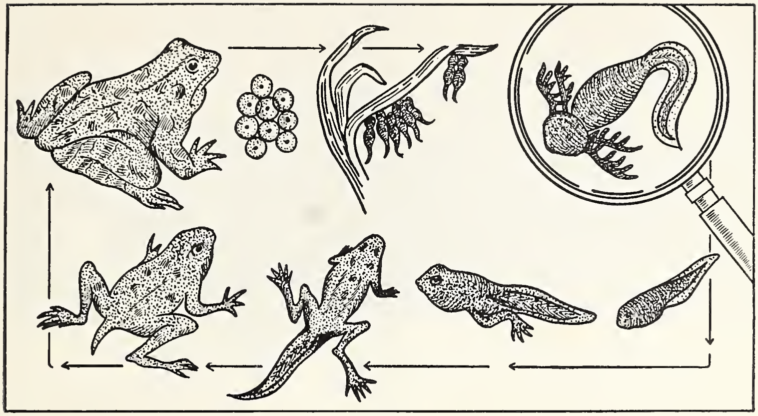
Flying fish and flying squirrels really glide after a rapid takeoff to get themselves into the air. Flying fish can glide in such a way as to obtain aid from the wind to stay in the air.

How do parts of organisms move? While locomotion looks more interesting than other bodily movement, it is no more important. There is constant motion of all parts of all living things. In plants, the juices flow from one part to another. In animals, the muscles of the digestive system, the breathing apparatus, and other important systems are quietly but constantly moving to perform their important work. An animal can live without locomotion for some time, but without motion of its body parts a higher animal can live for only a few seconds. Movement is one of the most important life functions.

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

The kind of motion that most animals have and most plants do not have is —1—. Leaves and stems tend to grow toward the —2—. The horse when —3— moves the two legs on one side at the time. The chief organ of the fish for moving ahead is its —4—. That kind of flight in which hawks sail without moving their wings is called —5—. The number of wings used by grasshoppers in flight is —6—; by butterflies is —7—. The number of legs all insects have is —8—. —9— move by first making themselves thick and then making themselves thin. The —10— is the only mammal which is adapted for flying.



The adult female frog lays eggs which hatch out tiny, gill-breathing tadpoles. What are some easily noticed changes which take place in the growing frog?

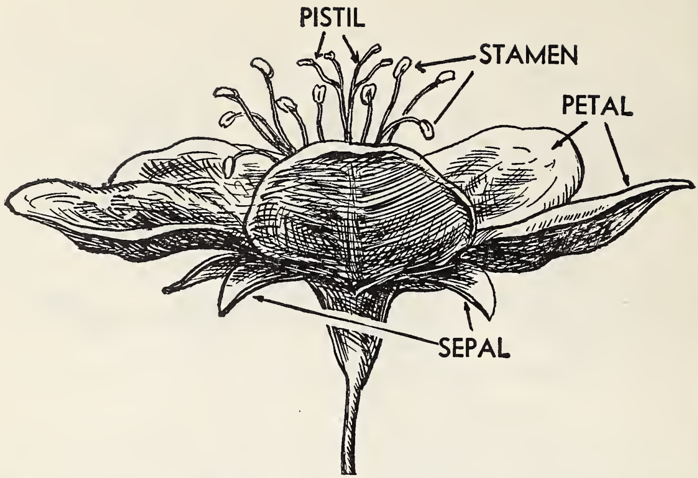
5. What is the cycle of life?

Every species must go through a certain cycle of life in order to maintain itself. Each new individual begins life, grows up, reproduces, and dies. The processes of reproduction and growth make it possible for life to continue.

What is reproduction? No matter how many kinds of living things you study—large or small, plants or animals—there are only two kinds of reproduction. An individual has either one parent or two. If there is only one parent, the individual has a chance to obtain only the good or bad characteristics of that one parent. The new individual can receive no ways of growing or acting beyond those passed on by its one parent. There is an advantage in having two parents, for each parent offers a chance for the individual to inherit [to obtain from a parent] something desirable. Of course there are just as many chances of inheriting undesirable characteristics as desirable.

The very simple organisms which have but one parent are formed by division of the parent cell. It merely goes through some complex changes of growth and splitting up, and where there was one individual there are now two. It is impossible to say which is parent cell and which is child, for the parent cell ceases to exist as an individual when it divides. Some algae reproduce by cell division, and so do many of the one-celled animals. Bacteria reproduce by cell division.

The more complex method of reproduction is for each of two parent organisms to provide one cell. These two cells grow together to form a single cell, and this cell develops into a new in-



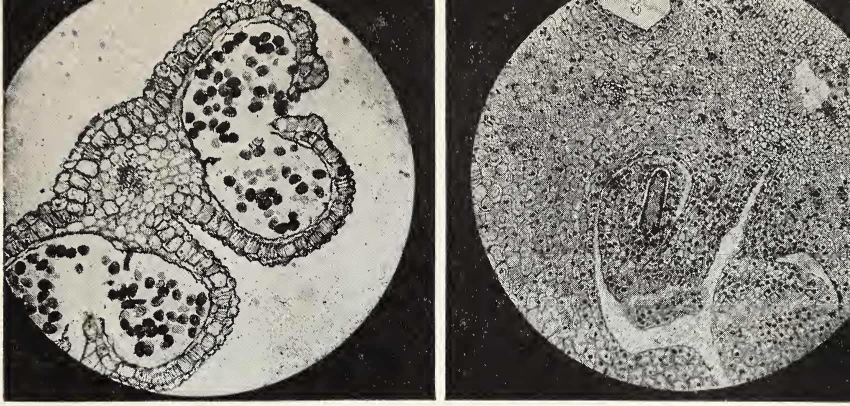
The flower consists of the pistil and stamens, which have the function of producing the cells which produce the new plants.

dividual. In the very simplest plants and animals, the two cells which join together are the two parent cells themselves. As far as can be determined the two cells are alike. Some algae grow together in this way, and form a small body called a spore. From this spore there eventually develops a new cell like the parent cells. It may then continue reproducing by dividing.

The more complex plants and animals develop from the union of two unlike cells. One cell is called the male cell, or sperm. The other is the female cell, or egg cell. The egg cell is always produced in an organ in a female organism called the ovary [ō′vȧ·rĭ]. There are many kinds of living things which produce these cells, and many ways of bringing them together and causing them to develop, but all accomplish the same thing—the production of a new individual.

How do seed plants reproduce? Some plants produce seeds in flowers. While we are accustomed to thinking of a flower in terms of its showy parts—the petals and other leaflike parts—these really are unimportant in the work of reproduction. The central part of a showy flower is a stalk, the pistil, often shaped like a long-necked bottle. The base of the pistil contains a hollow space, the ovary. In the ovary the egg cells are formed. Around the pistil of the usual showy flower is a row of threads called stamens. These stamens produce the pollen grains, which eventually produce sperm cells.

Some flowers do not have any petals at all, and may have only a pistil or only a stamen. The stamen flowers of corn are the



These pictures were taken through a microscope. On the left is a lily stamen cut to show pollen grains. On the right the pistil is cut to show the egg cell in place in the ovary.

tassels or top flowers. The pistil-bearing flowers become the ears. The corn silk is part of the pistil.

The chief problem of flowers is to get the pollen grain carried to the pistil. Showy flowers attract insects that do this work. They provide a sweet food called nectar to attract them, and by their showy colors and odor advertise their presence to the insects. Corn and most of the other grasses depend upon the wind to carry their pollen. The pine trees produce so much pollen that it sometimes collects on the ground and looks like sulphur.

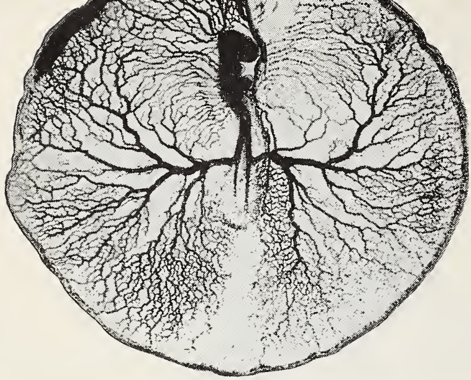
If a pollen grain falls upon the pistil, it immediately sends a rootlike tube down the inside of the pistil to the egg cell. The tube is watery, and the sperm cell flows down it to combine with the egg cell. As soon as the two cells unite, a new plant is started on its way into being. Sperm cells of one kind of organism cannot combine with egg cells of another kind of organism.

How do complex animals reproduce? An amazing number of living things develop from eggs. Flies, chickens, turtles, fish, frogs, earthworms, crayfish, snails, and snakes generally hatch from eggs.

The problem of fertilizing [uniting of egg and sperm cells] the egg is more simply solved by water animals than by land animals. The method of the fish is one way of solving the problem.

The eggs are produced in the body of the female fish. They pass from her body into the water. The male fish stays near, and sperm cells pass from his body into the water at the same time the eggs are laid. The sperm cells have little whiplike tails and swim around. Some of them bump against the egg cells, and they unite, completing the process of fertilization.

Land animals generally cannot use this method, although one group, of which the frogs and toads are members, do lay their



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If you should break an egg that has been warmed by the mother hen for 48 hours, this is how you would find the baby chick developed. The lines are blood vessels which grow out to absorb food from the egg for the tiny chick.

eggs in water. Male land animals are adapted to deposit the sperm cells in the body of the female animal, so that they unite with the egg cell before the egg is completely formed.

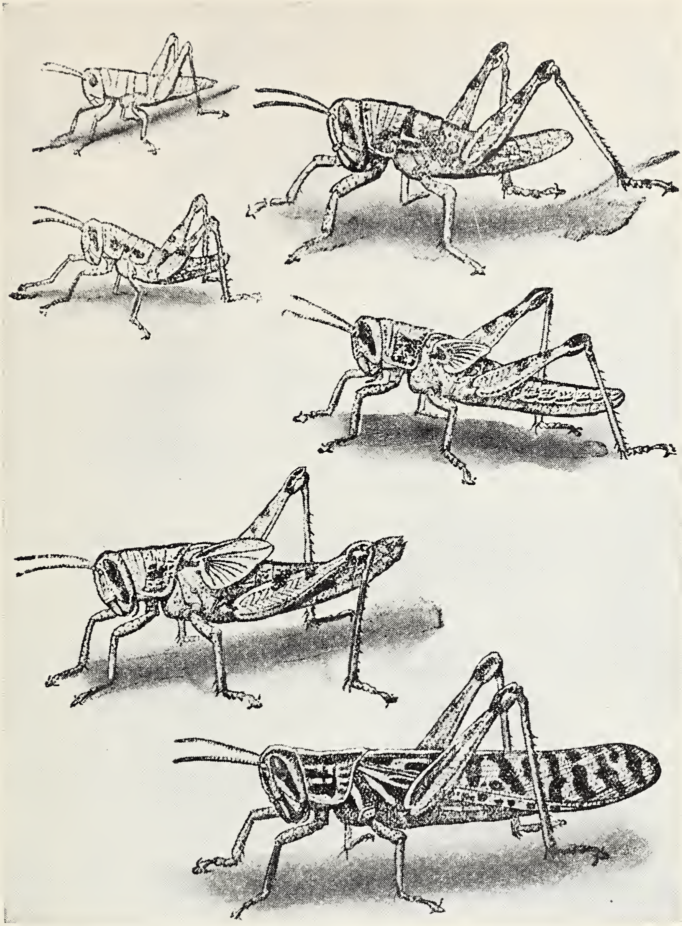
Eggs laid where they are exposed to the air are not exactly like eggs laid in water. Both contain a fertilized egg cell and a supply of food for the young animal. But eggs laid in water are jelly-like, and have no special protection, while those which are laid exposed to the air have a covering or shell of some sort which keeps them from drying out.

When the egg cell is fertilized inside the body of the female animal it is not always laid as an egg. Instead it may develop inside the body of the female until it is large enough to survive after birth. The undeveloped young animal is better protected and better nourished inside the female animal's body than it could be anywhere else.

Animals which produce their young alive are more successful in bringing them to maturity [the condition of being fully grown] than are most other animals. Although a cow has but one calf each year, cattle survive because of the care cattle give their young. To keep the species of a certain kind of fish alive, one female fish may produce thousands of eggs, all but one or two of which fail to develop to fully grown fish. Many fish eggs are eaten by water animals, many are not fertilized, and many young fish provide food for larger fish.

How do some plants grow? When anything grows, it may do two things. It may increase in size and it may add new parts. The tiny undeveloped plant—the embryo [ĕm′brĭ·ō]—in the seed does not look very much like a plant, even when magnified greatly. The seed contains stored food which gives this new plant its start. Stimulated by warmth and moisture the embryo forms roots and a stem. The parts of the seed may serve as the first leaves, as is the case with beans. Ordinary leaves develop later. Those plants that have seeds consisting of only one part, of which corn is an example, send out a stem and leaves from the developing embryo.

The flower does not develop until the plant is almost mature. Usually the growth of those parts

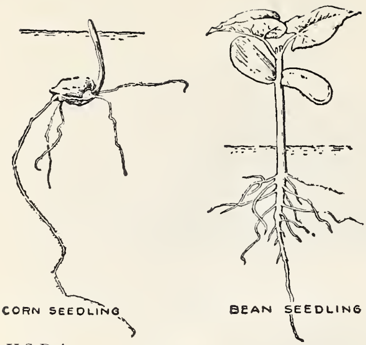


U. S. Bureau of Entomology and Plant Quarantine

The grasshopper does not go through four stages of growth. Each time it grows larger by shedding its old skin and growing into another, more advanced, stage. The early stages do not have wings, and the very first stages are about the size of a pinhead. Compare this with the growth of a fly (page 116).

which are required for reproduction are the last to complete their growth.

How do insects grow? Insects follow two different patterns of growth, depending upon the species. One large group goes through four different stages, each much unlike the others. From the egg there hatches a wormlike creature called a larva. It has a few parts we expect to see



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Different types of seedlings grow differently. The seed leaves of the corn and pea remain underground, but the seed leaves of the bean push upward through the soil. Note the difference between corn and bean roots.

in adult insects. It is well adapted for eating and increases greatly in size. When it has reached a certain size, the larva changes into a pupa. The pupa stage of moths is spent in a cocoon. That of some beetles is spent in a kind of case made in wood. All kinds of pupae spend this stage in some protected place.

During the pupa stage another kind of growth occurs. The many parts of an adult insect develop—legs, feelers, new eyes, wings, and reproductive organs. From the pupa stage the adult insect comes complete and ready for its grown-up existence.

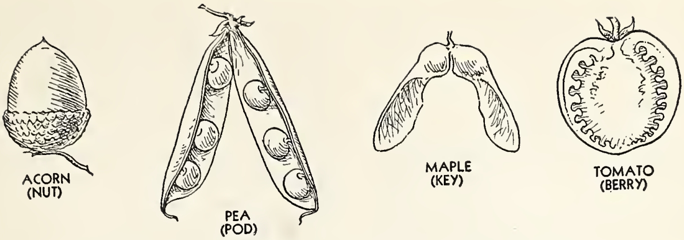
Many insects go through only three stages. The middle stage is called a nymph. In most cases it looks somewhat like the adult insect, but does not have wings nor developed reproductive organs. Sometimes nymphs live in environments different from those where the adult lives. The dragonfly nymph lives in water. The grasshopper is the commonest insect that goes through only three stages of growth. Its nymph stages look enough like the adult grasshopper that you can recognize it.

How do larger animals grow? You are familiar with the story of the growth of frogs and toads. The eggs hatch in water, producing tadpoles. The tadpoles have tails and no legs. The tails and gills gradually disappear, and legs, lungs, and other adult parts develop. When it becomes an adult the frog is ready to live on land and cannot breathe in water. Other large animals grow in ways familiar to you. You have seen young birds, kittens, and babies grow toward the adult stage.

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

—1— is the life function necessary for the survival of the species. The simplest way of producing new organisms is by cell —2—. The male parent produces the —3— cell, and the female parent produces the —4— cell in an organ called the —5—. The —6— of a showy flower is bottle shaped, and produces the egg cells. The stamen produces the pollen grains which produce the —7— cells. The eggs of fish are —8— in water. Union of egg and sperm cells is called —9—. The undeveloped



These fruits—the seed container and the seeds and the attached fleshy parts—differ from our everyday idea of what a fruit is. Yet all are fruits as the scientist uses the name. How do the fruits help to protect and scatter the seeds?

plant in a seed is called the —10—. The wormlike stage of an insect's growth is the —11— stage. Many insects go through a quiet —12— stage during which adult organs grow.

6. How are young organisms helped to grow?

You can see that a tiny plant in a seed or a baby bird in its nest is quite helpless. Neither can move enough to seek food, nor to find a more favorable environment. Many kinds of plants and animals are adapted to give the young some help in getting a start in life. Plants scatter their seeds far and wide. Some animals place their eggs where food will be available for the young. A few animals give their young excellent care.

How are seeds scattered? The flower develops into a fruit. All the parts drop off but the ovary, in which the seeds are located. As the ovary and seeds ripen a fruit is produced. The name fruit is used to include the ripened ovary, whether it has sweet fleshy parts or not. Many fruits are useful to the plant in scattered seeds.

It is necessary for the seeds of a plant to scatter. For example, if all the many seeds that an elm tree bears were to fall directly on the ground near the tree, there would be little chance for them to grow in such a small space. But as the wind scatters them around over a large area, they have a much better chance to find space in which to grow.

Seeds are scattered in several ways. Some plants scatter their seeds themselves, but most of them are adapted to make use of the wind, water, or animals to disperse their seeds for them. The witch hazel is a plant which can scatter its own seeds. It scatters them much as you shoot an apple seed by squeezing it between your finger and thumb. Other plants throw their seeds by a sudden snapping of the parts to which they are attached. The next time you find the touch-me-not plant, pinch the end of the

pod, and you will be surprised to see how quickly the seeds shoot out.

Some seeds are attached to tiny hairs which look like plumes. The dandelion seed may float several hundred miles through the air, the hair serving as a tiny parachute carried along by the wind. Seeds of the maples and elms are provided with wings. These seeds are not carried long distances, but spin and whirl through the air to fall some distance from the tree.

Tumbleweeds and some mustards break off when the seeds are ripe, and the light, ball-shaped plants are rolled along by the wind, scattering their seeds as they go.

Some seeds, such as those of the burdock, have little hooks by means of which they stick to the hair of animals and to people's clothing. These seeds may fall to the ground after being carried long distances.

Some birds eat the fleshy parts of fruits or the insects which live in the fruit. As the birds eat into the fleshy parts, the seeds may fall to the earth, or if the fruit is small it may be carried great distances and dropped. If they are eaten, seeds may pass undigested through the body of an animal or bird and be dropped to the ground far from where they grew. It is interesting to note that before the seeds are ripe the fruit is green. At this time the birds do not bother the fruit. But as the seeds ripen, the fruit changes color and becomes good to eat. Then the birds become very much interested in it.

Do insects care for their young? Most insects give their young no care at all. The grasshopper lays her eggs in the ground during the autumn, and then dies when winter approaches. The young grasshoppers that hatch out in the spring never see their mother. They begin at once to find their own food.

However, some insects lay their eggs on or near the food supply of the young. The potato beetle lays her eggs on the potato leaves on which the young feed. Certain wasplike flies lay their eggs upon the larvae of other insects, which the young devour for food as they hatch from their eggs. One of the wasps puts a spider into its nest along with the eggs to provide food for the young when they hatch. The wasp, by stinging the spider, paralyzes it so that it cannot escape or eat the eggs, but still remains alive.

There are some insects that feed their young and furnish a nursery to protect them. The honeybee and the hornet feed their young daily as they grow up. Other insects provide enough food at one time to last the young until they can find their own before they leave them.

How do birds care for their young? In the early spring the male and female birds mate and undertake the work of raising a family of young birds. The work begins by building a nest in

which to rear the young, for adult (grown-up) birds do not live in nests. Both parent birds may make the nest or the female alone may do it. A great variety of materials may be used. Of these, dried grass is one of the most common. The robin uses mud; the chipping sparrow, horsehair; the Baltimore oriole, grass and string; and the catbird, the bark from a grapevine. Usually the inside of the nest is lined with a finer material.

Birds build their nests in a variety of places. Quail and most ducks build them on the ground. Many birds build them in the forks of trees and shrubs. The woodpeckers chisel out a flask-shaped hole in a tree, but they build no nest. The kingfisher and the bank swallow dig holes in a bank, the latter nesting in large colonies. The house wren places its nest in almost any cavity. It may be in an open mailbox, in a clothespin bag hanging on a line, or even in the pocket of a coat worn by a scarecrow. Nighthawks lay their eggs on a bare rock surface.

In the nest the female bird usually lays from one or 2 to 12 or even 20 eggs, the number varying with different kinds of birds. Eggs of some birds blend in color with the surroundings. The eggs must be kept warm by the heat of the bird sitting on them. Most of this work of incubation [ĭn′kū·bā′shŭn] is done by the mother. The time required for the eggs to hatch varies with the size of the eggs. For a bird like the robin it takes about two weeks.

The care given young birds depends upon their condition when first hatched. Young songbirds are blind, naked, and helpless. The chief work of the parents is to furnish enough food to meet the constant demands of the hungry young birds. Young songbirds are fed chiefly on insects. Feeding is a continuous process, beginning at sunrise and continuing till sunset. During the long summer days in the northern states the parent bird works 15 hours a day.

On the average, songbirds feed their young 200 times a day, or an average of once every four minutes. One pair of wrens was seen to feed its young 350 times between sunrise and sunset.

The birds which produce from 12 to 20 eggs, such as ducks, quail, and rails, do not feed their young. The young of these birds can obtain food for themselves soon after they hatch. Owls and kingfishers which catch large prey lay from 6 to 10 eggs. Thus you see that the method of feeding the young and the number of young is closely related.

The rapidity with which young birds grow up is surprising. A young bird often eats its own weight of food in a day. And during this same period it increases in weight 50 per cent. The average time that young birds remain in the nest is about two weeks, although some leave the nest immediately after hatching.

How do mammals care for their young?. Those animals which feed their young on milk are called mammals. All of the common hairy, four-legged animals belong to this group: cats, pigs, cows, squirrels, and many others. It is interesting to note that the milk which the cow gives to feed its young is the best single food for growing boys and girls.

The number of young that mammals raise at one time varies with the animal. The cow, the horse, and the elephant raise but one. The bear raises two; the cat and the squirrel, from three to six; and the pig, from four to fourteen.

The length of time that the mother feeds the young varies with the kind of animal. Most mammal mothers protect and care for their young in many ways. You may have seen a mother cat wash her kittens, carry them in her mouth, punish them for being naughty, and teach them to hunt.

What other animals care for their young? Many spiders make silken egg sacs in which the eggs are placed. The running spider drags this egg sac after her. When the young hatch out, they climb on their mother's back and remain there for a time.

The little stickleback is an unusual fish. The male builds a nest to protect the eggs laid by the female. This nest is made of pond scum and is fastened to the stem of some water plant. The fish gives out a kind of waterproof glue which he uses in making his nest. The female lays her eggs inside this nest. The male then stands guard at the door of the nest, driving off all intruders. Here he remains on guard till the eggs hatch and the young fish come out of the nest.

DEMONSTRATION: OF WHAT DOES A SEED CONSIST?

What to use: Dry and soaked Lima beans.

What to do: Soak some beans at least 24 hours in warm water. Compare the soaked beans with the dry beans. How do they differ? Carefully remove the seed coat of a soaked bean. Open the two halves of the bean. First find the seed leaves. They are the large fleshy halves. Next look for the tiny rodlike stem. On one end of this stem is the point from which the root is to grow. On the other end of the stem tiny, leaflike parts may be seen. These become the leaves of the young plant.

What was observed: Make a sketch to show what you observed.

What was learned: List all the parts of a seed, and state their functions.

Things to think about

Match the following subjects and predicates. Copy the sentences in your notebook.

Subjects

1. Plants which have seeds scattered by wind

2. A fruit
3. Most insects
4. Birds which produce young ready to feed themselves
5. A bird's nest
6. The period of incubation
7. Those animals that give milk
8. The young of songbirds
9. The stage of growth in which plants can move from place to place

Predicates

A. usually lay 10 to 20 eggs.
B. include thistles, elms, and dandelions.
C. are called mammals.
D. is used only as a nursery.
E. are fed chiefly on insects.
F. consists of a ripened ovary and the attached parts.
G. is the time required for eggs to hatch.
H. lay their eggs near a supply of food for the young.
I. is when the young plant is in the seed.

7. Are there advantages in living together?

Some animals live together merely because by chance they are in the same locality. Other animals live together in groups because of the advantage of numbers in providing defense or in hunting food. Each of these animals does about the same things it would do if living alone, except that several animals working together make the work easier.

A third type of group living provides opportunity for different individuals to do some special kind of work, while other individuals do different work. Most of the animals of this kind fall into one of four groups, the ants, the bees and wasps, the termites, and men.

Sometimes plants or animals of different kinds live together. Ferns live in the shade of trees, and their presence helps to keep the soil of the forest floor in good condition. Cowbirds live around cows in order to peck insects from their backs. This may help the cows to some extent by removing insects.

How do honeybees live? The most useful and the best known of the social insects are the honeybees. Within each colony are found three kinds of bees: the queen, the drones, and the workers. The queen and workers are females, and the drones are males. The worker is the smallest, and the queen and the drone are about the same size, except that the queen has a more slender body. In a large colony there may be as many as 50,000 workers, while there are only a few hundred drones and usually only one fully grown queen. In an old hive the drones and workers are children of the queen.

The queen bee has but one function—to lay eggs. This work keeps her busy, because when the honey-making season is at its height, she may lay as many as 1500 eggs in a day.

The workers build the cells of


U.S.D.A.

The bees have a highly complex life. The queen bee with the long body has her head in a cell examining it before laying an egg in it. The other bees are workers.

the comb, gather food, and feed the young. To build the cells, certain of the workers gorge themselves with honey and then change the honey into a wax in their bodies. As it is produced, it is forced out in tiny places from the underside of the body. Other bees remove the wax and use it to build the six-sided cells.

The cells serve two purposes. They are used as nurseries to raise the young bees, and they are used for storing food.

The older workers gather two kinds of food materials—nectar and pollen. They suck up the liquid nectar from flowers into honey sacs in their body. There it is changed by juices produced in the bee's body. When they return to the hive, this changed liquid is deposited in the cells. The cells are left open until some of the liquid has evaporated, and then the cells are capped. Bees do not gather honey from flowers; they gather nectar, which is later made into honey.

The pollen sticks to the mouth and hairs on the bee's body and is later pushed back into a pollen basket located on the hind pair of legs. When it is filled, the bee returns to the hive. There it scrapes the pollen from the basket by means of a little spur attached to one of the legs. This pollen is stored in the cells as beebread to be used for feeding the young.

The younger workers take care of the feeding. A recently hatched larva in each cell is fed many times during the day. When the larva has stopped growing and is ready to go into the pupa stage, the cell is capped

over. During this period the bee develops into an adult. When grown, it gnaws off the cap and comes out to take its place among the nurse bees.

The bees are able to control in two ways the form the adult will take. If the queen lays an egg that is not fertilized—that is, an egg that is not united with a male or sperm cell—this egg always develops into a drone. If the queen lays an egg that has been united with a sperm, this egg becomes either a queen or a worker. Which it shall be depends upon the kind of food it is fed. If it is fed a rich food called royal jelly, it becomes a queen; but if it is fed ordinary food, it becomes a worker.

When the workers become very numerous in the hive, the old queen leaves the hive, and is accompanied by a part of the workers. This is called swarming and takes place when new queens have hatched for the old colony. When there is to be no more swarming, one of the new queens is allowed to sting the other queens to death. This is the only way the sting of the queen is ever used. The only time the mature queen leaves the hive is when mating or swarming.

Are hornets social insects? The bee colony goes on from year to year, but the colony of some social insects lasts but one season. Among the hornets the queen lives through the winter, but all the others die. The queen must start a new colony in the spring.

The queen begins the colony by building a cell. As soon as it is finished, she lays an egg in it and builds more cells and deposits more eggs. Her work increases rapidly, because as the eggs hatch she must also take care of the feeding. The young are fed a kind of honey, made from nectar, and chewed-up pieces of caterpillars. When the young are full grown, they help feed the other young so the queen mother can give more of her attetion to laying eggs. These young hornets are imperfectly developed females and may be compared to the workers among the bees.

As the workers become older, they assist in making the nest larger. The floors are made larger, and new floors are added. Since the nest is fastened to some branch, the top floor is made first. As the number of workers increases, the nest grows very rapidly, and the queen is then able to devote her whole time to laying eggs.

Hornets gather bits of dried and rotting wood and work it over in their jaws until it becomes a sort of crude paper. The nest cells are made of this paper. Three different grades of paper are used. The crudest is that found on the outside covering the whole nest; the second is that used in the construction of the cells; and a third grade, much finer than either of the others, is used to cap the cells.

In the early fall, both males and fully developed females develop. After mating, the males

die and the females find protected places where they can spend the winter. The workers die when cold weather comes, thus leaving the queen to build the new colony the following year.

Are ants social insects? There are many kinds of ants, but all ants are social insects. There is usually a queen ant capable of laying eggs, worker ants which care for the nest, and soldier ants. Some ants develop highly specialized abilities. One kind of ant cuts and carries leaves. Some kinds of ants grow crops, either above ground or in their burrows. All ants care for their young. Nurse ants carry eggs and larva to the proper level in the nest to provide best temperature conditions. They lick the young clean.

Some ants are fierce fighters. These soldier ants raid other nests and capture worker ants which they use as slaves. Some soldier ants cannot even feed themselves. Ants are highly specialized insects.

Things to think about

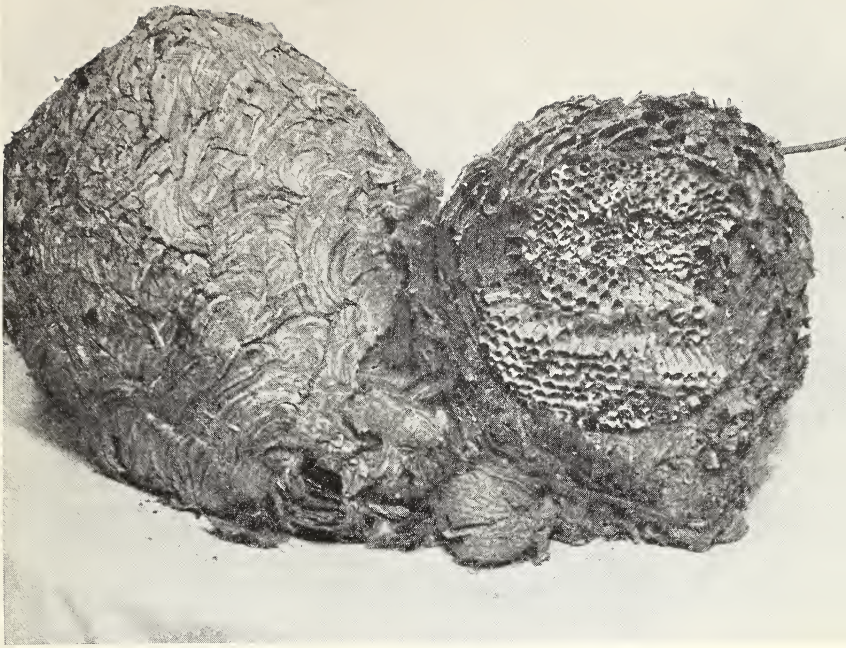
Copy the following paragraph in your notebook. Complete the sentences.

In colonies of social insects various individuals have —1— abilities. The work of the —2— bee is to lay eggs. Bees gather —3— and —4— from flowers. Honey is made out of —5—. Pollen is carried by bees in a pollen —6— found on their legs. The nest of hornets is made of —7—. The —8— is the smallest of the three types of individuals in a colony of honeybees. The only males in a colony of honeybees are the —9—. The —10— in a colony of honeybees have a grandfather but no father.

A review of the chapter

Living things differ from nonliving things in that they can grow, repair themselves, and perform other life processes. These life processes include food-getting, taking in air, movement, reproduction, and ability to adapt to a changing environment. The environment is the source of all materials and warmth required to carry on the necessary life processes.

Each type of organism has its own particular ways of meeting the problems shared by all living things. Different kinds of animals living in the same environment, although they may be greatly different from each other in most ways, tend to meet some life problems in similar ways. Thus gills are common to several types of animals. Some animals form colonies for their advantage in solving life problems. Every living thing found in the so-called temperate climates must be adapted in some way to meet changing conditions caused by changing of the seasons.



A hornet's nest is safe to examine only when the hornets are not living in it! The nest is made of a paper covering and of layers of paper cells in which the young hatch out and develop.

Word list for study

Be sure that you can pronounce, spell, define, and use in a sentence every word in this list. Each of these words has been defined or explained and used in this chapter.

environment	adapted	function
migrate	algae	chlorophyll
hibernate	organism	stomate
fungi	rodents	spiracle
trachea	larva	mammal
locomotion	reproduction	inherit
ovary	pistil	stamen
egg cell	pollen	sperm cell
growth	embryo	pupa
nymph	incubation	social

An exercise in thinking

Below are two groups of sentences. The first group contains principles, which are large general ideas. Each sentence in the second group contains an idea related in some way to one of the principles in the first group. Write the numbers from 1 to 35 on a piece of paper or in your notebook. Find the principle which best explains the idea in the second list. Then after the number on your paper write the letter before the related principle.

List of principles

A. The environment of an organism provides all things necessary for its survival.

B. Living things must be adapted to carry on all the fundamental life processes.

C. Green plants are the only forms of living things capable of making their own food.

D. Plants and animals depend on each other for many things.

E. Living things come from other living things of the same kind.

F. Living things are able to adapt themselves to changing conditions.

List of related ideas

1. A toad catches insects with its tongue.
2. Green plants take in air through holes in the surface of their leaves.
3. The green material (chlorophyll) helps the leaf make food.
4. Animals depend on green plants for their food.
5. A seed contains food and a small plant.
6. Many birds migrate southward in the autumn.
7. Most plants cannot live on deserts.
8. Many flowers are pollinated by insects.
9. Egg cells are formed in the ovary.
10. Some animals hibernate.
11. Most living things require oxygen.
12. Fishes take in air through their gills.
13. Before seeds can form, flowers must be pollinated.
14. Toads lay their eggs in water.
15. Many seeds live through the winter.
16. Agricultural ants raise seeds for food.
17. Robins lay their eggs in nests.
18. Many trees drop their leaves in the autumn.
19. All living things require food.
20. Mammals take air into their lungs.
21. Sugar-making by green plants takes place only during the daytime.
22. Many seeds are scattered by animals.
23. Mammals feed their young on milk.
24. The leaves of the white clover close at night.
25. The water which the plant uses in making food is taken from the soil by the roots.
26. A weasel turns white in winter and brown in summer.
27. Some organisms reproduce by cell division.
28. The larva stage of insect growth is adapted for eating large quantities of food.

U. S. Forest Service

Among the mammals, the mother usually cares for the young.

29. By being able to travel readily, birds obtain food from fairly large areas.
30. Sugar is the first stage of making all food.
31. The work of reproduction is carried on only by adult animals.
32. A one-celled animal takes food through its cell wall.
33. The beaks of hawks are curved and sharp.
34. Elm trees shed their leaves in the autumn.
35. The bones of some birds weigh no more than their feathers.

Some things to explain

1. What is the relation between a bird's food and its bill?
2. In what ways are the life problems of man similar to the problems of other animals?
3. In carrying on the essential life processes, what are the chief differences in the adaptations shown by water animals and the adaptations shown by land animals?
4. If pollination by insects were to cease, how would man be affected?
5. How is the social life of hornets different from that of honeybees?
6. Is man a meat eater, a plant eater, or a mixed food eater?

Some good books to read

Comstock, A. B., *Handbook of Nature Study*

Clark, A. H., *Animals Alive*

DuPuy, W. A., *Our Insect Friends and Foes*

Fenton, C. L., *Our Living World*

Kenley, J. C., *Green Magic*

Kane, H. B., *Tale of the Promethea Moth*

Kane, H. B., *Tale of the White-Faced Hornet*

Platt, R. H., *This Green World*

CHAPTER

12

Enjoying a Garden

Before we start a garden, we need to decide the kind we wish to have. If there is plenty of room, both flowers and vegetables may be raised. Whatever the kind, its arrangement must be carefully planned. If the garden is for decorative purposes, the types of plants chosen will be different from those which would be used if we were raising food for the table. But our planning will not be complete even when we have decided upon certain species of plants. We need to select the particular variety of the plant which will be best suited for the place and the purpose we have in mind.

Gardens may be planted either indoors or outdoors, but those outdoors provide activity in the sunshine and fresh air. Vegetables may be raised in outdoor gardens, for use or for sale. Raising them will require only a reasonable amount of time and not too much work.

Gardens are also planned for decoration. The appearance of any place, no matter where it may be, is improved by growing plants. Unattractive places, such as bare walls, blank corners, or unsightly sections of the yard, may be concealed by the proper use of plants and shrubs.

Before we are ready to start work on our garden, we need to know how to prepare the soil and start the plants. We must be able to recognize weeds and know how to get rid of them. And as the plants grow, we should understand what care they need. When we have this information and have applied it in our garden, we may consider ourselves successful gardeners.

Some activities to do

1. Make an indoor garden in your classroom. Let each pupil, or a small group of pupils, set up one flowerpot containing a plant. Give the plants good care and observe how they grow.

2. Test some seeds. Get two plates and some blotting paper. Put two pieces of blotting paper on one plate.

Moisten the paper. Put some seeds on the paper. Place a piece of moist blotting paper over the seeds. Invert a second plate over the paper. Put in a warm place and keep the paper moist. What per cent of the seeds germinate?

3. Plan a garden for your own home grounds, following the suggestions of this problem.

4. Make a school garden on a vacant lot or in the schoolyard.

5. Organize a 4-H Club and join the national organization.

6. Make a collection of weeds. Put the plants between the pages of a magazine and place some weights on top. After they have stood for two weeks, mount each weed on a sheet of paper, fastening it with gummed stickers. Under the weed write its name.

7. Visit a commercial greenhouse or truck garden.

8. To show how a soil mulch helps keep water in the soil, do the following experiment. Put some powdered sugar on a lump of sugar. Place the lump in a little ink.

Robert McFerran

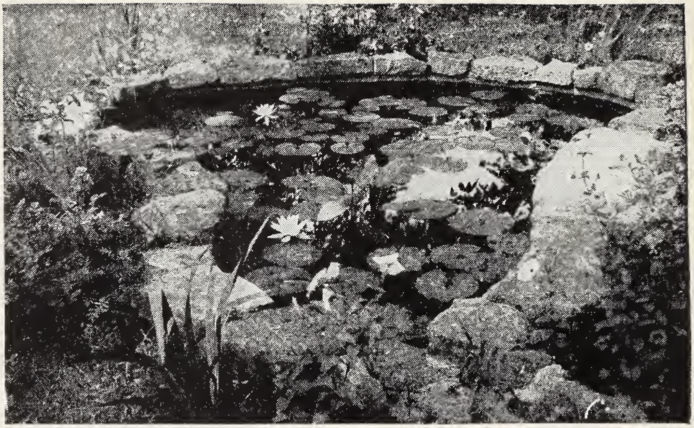
Irises are commonly planted to form borders around the yard and garden. They may be obtained in many beautiful colors.

Some subjects for reports

1. How a new variety of plant is developed and marketed
2. Best varieties of apples or other fruits for your region
3. Your own experience with your first garden
4. New kinds of chemicals used in sprays
5. Advantages and disadvantages of different kinds of trees in yards
6. Varieties of plants especially developed for freezing or canning
7. The advantages and disadvantages of storing foods in deep-freezers
8. The 4-H Garden Club program
9. Dates of last and first killing frost in your neighborhood
10. Advertising statements and factual information in seed catalogs
11. Tools needed in a family garden and their use and care

1. Why should we plan our garden?

How we plan our garden will depend upon our needs. Our garden may be located in the sun or in the shade; on the north



A pleasant pool with water lilies and goldfish is an attractive ornament to the home yard. What precautions must be taken when there are children of the toddling age in the family?

side of the house or on the south side; in good soil or in poor. We may live in a climate with a short growing season or a long one. We may wish to obtain the largest possible amount of food from a small space; or we may wish merely to grow a few vegetables that taste better fresh from the garden. It is better to have a well-cared-for small garden than a neglected large garden.

What are the different types of gardens? The word garden may be used to include a place used for growing vegetables or flowers, or it may apply to any grouping of plants around the home. In this larger meaning of garden we include the decorative gardens. One type of decorative garden is formal in arrangement. The flowers are planted in beds, the shrubs are in clipped hedges, and the trees are shaped by trimming. The natural type of garden depends for its appeal upon arranging flowers, trees, and shrubs to grow in their natural manner, while producing a pleasing effect.

Plants may serve several purposes around the house. They may be used to hide unattractive parts of the house or its equipment. They may serve as boundaries between lots. They may help to display attractive parts of the house. Plants may be used as screens to insure privacy. They may be used to provide shade for coolness in the summer or as windbreaks to protect against cold in the winter.

How should trees be used? The proper use of trees is a particularly difficult problem. A tree is small at first, but eventually grows so large that one tree may cover much of the lot. There are several ways of managing trees. One way is to plant a few quick-

growing trees, such as poplars, for quick shade and screening, and to plant more useful trees, such as walnuts, oaks, and maples for permanent growth. As soon as the valuable trees are large enough, the quick growing trees can be removed. Another way is to use shrubs to screen the house while trees are growing, and then as the trees gain in size to remove the shrubs.

Trees which are too large and old, and close to the house, present a real source of danger during storms. One should not hesitate to remove an old, oversized tree provided that a smaller tree has been started to take its place. A fruit tree twenty to thirty years old generally yields poorly and should be replaced. New trees should be planted far enough from the house and from other permanent trees to allow room for growth. A pine or elm may grow to a height of 60 or 80 feet, and will eventually cover most of a lot with its shade. Fruit trees should be planted in a part of the yard where falling fruit will not be a nuisance. Nut bearing trees may be planted in any part of the yard which is suitable.

How is the yard planted? If the front yard is on a standard small lot in a city or town, the chief function of the front-yard planting is to provide an attractive view from the street. Frequently trees or high shrubs are placed at the corners of the house to frame it or to make the lines of the roof less abrupt. Shrubs should not be planted on the street corner of a corner lot because they are dangerous traffic hazards. Along the foundation of the house are planted shrubs and low evergreens, to hide the bare foundation and to provide a background for other plants. If there is enough space, low-growing flowering plants are used in front of them.

The lawn is the most important part of the front yard. A carpet of green grass is attractive, even though no other plants may be used. The lawn area should be kept open and not broken by shrubs, flower beds, or trees.

Along the borders of the yard either flowers or hedges may be used. Neighbors may join their lawns to give the impression of greater spaciousness, needed by many crowded houses. Trees should be planted in the space usually left between the sidewalk and the street.

The problems of apartment houses and larger homes are about the same as those of the small home, except that the matter of selection of plants is somewhat different, and larger masses are needed to produce a balanced effect.

If the lot is small, only a few foundation plants are needed at the sides. If it is large, the same method of framing the house from the sides may be worked out as is used at the front.

The backyard is used for a working and living space. Here are located the clothes-drying racks and the vegetable garden. It may also be used as an outdoor

living space for the whole family or as a play space for children. The outdoor living space is planned like a room, with tall plants used for walls surrounding an open space. This space, perhaps shaded by trees, is pleasant for resting, reading, or eating. Flowers may be grown at the foundation of the house.

The vegetable garden may have flowers in it to be cut for use indoors, or it may have a decorative border of plants to separate it from the living space. Tall shrubs around a vegetable garden would shade the vegetables and are not desirable.

What plants may be used in yards? Where the winter temperature drops below freezing, it is desirable to have some kind of evergreen in the yard. Common evergreens used for this purpose are arborvitae, junipers, spruce, and pines. Deciduous [dė·sĭd′ū·*ŭ*s] trees are beautiful in summer, but since they drop their leaves in autumn their bare branches are not as attractive in winter as are evergreens. Deciduous trees permit more light to fall on the house in winter, however.

In the Southeast there are so many plants adapted to use in yards that the problem is one of obtaining a desired effect rather than one of finding plants which will grow. In the dry Southwest it is necessary to use cactuses, ivy, and other plants that require little water.

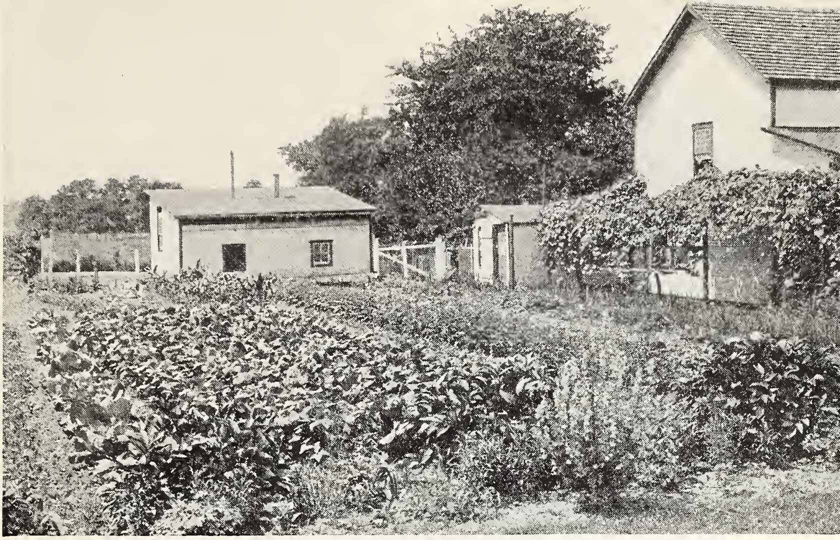
The selection of shrubs is determined almost entirely by the climate. The farther south one goes, the greater are the variety and abundance of flowers. Shrubs selected for hedges must be able to withstand trimming without injury to the remaining parts.

For planting along north walls, ferns are often about the only plant that will grow luxuriantly. Sometimes wild flowering plants may be found growing in the shade of forest trees, and may be adapted for garden use. Do not destroy wild flowers in large quantities for experiments that will possibly fail.

To obtain the earliest blooming flowers in the spring, perennials are used. Perennials are plants which last for several years. The familiar snowdrop, crocus, and jonquil appear in northern states almost as soon as the snow is gone. Perennials require less care from year to year than do annuals but require a longer time to start. Annuals are planted each year, and as a result come into bloom later in the season. They bloom the same year they are planted.

The best combination of evergreens, shrubs, deciduous trees, annual and perennial flowers, and lawn can be decided only after study of the space available; the amount of time available to develop the garden; the climate; the soil; and the plantings of neighboring areas.

Where should the vegetable garden be located? It is easier to cultivate a vegetable garden if the rows are fairly long. The vegetable garden will not produce if



A backyard garden can supply enough vegetables to make a definite difference in the cost of food. Sweet corn, cabbage, tomatoes, green beans, radishes, and lettuce are easily grown.

it is shaded. The garden of usual size will be reserved for such quick-growing small vegetables as lettuce, peas, beans, parsnips, and tomatoes. It is not likely that the yield of potatoes, squash, or melons would justify the large amount of space they require. Thus the kind of vegetables grown will depend upon the space available. The vegetable garden is almost always part of the backyard.

Your own desires will determine the use you make of the land available. Before you decide what to do, you can obtain much useful information from seed catalogues, which may be obtained free from various seed companies.

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

Shrubs should not be planted in the center of the —1—. —2— plants live but one season; —3— live more than two years. Flowers that bloom the same year they are planted are called —4—. —5— grow well in the shade. The most important part of the home yard is the —6—. Plants located near the house are called —7— plantings. —8— trees drop their leaves in the autumn, but —9— trees do not.

2. Can we have indoor gardens?

In some sections of the United States, gardens grow all year around. But in most parts of the country, there is a large part

The begonia is one of the most desirable house plants. It bears a profusion of pink blossoms and has beautiful foliage.

of the year during which it is too cold to have an outdoor garden. We can grow either useful or decorative plants indoors.

Many people who try to grow houseplants do not have as much success as they might because they do not use the right methods of providing for the needs of the plants. Common mistakes made are using flowerpots which are too small, letting plants become too dry, keeping plants in light which is too dim for their needs, or watering too much when the drainage is poor.

What equipment do we need? A few plants will grow in a bowl of water in places where light is dim. One is the philodendrum, a vine with green and white leaves. It is often used on the mantel or on a bookcase.

Most plants require considerable light and good soil. The soil may be made by mixing good garden soil with a little well-rotted manure or plant fertilizer. If the soil is too heavy some fine sand should be mixed in. A good potting soil will crumble when moist and will not pack hard when dry.

Common clay flowerpots at least 5 inches in diameter provide best conditions for growth of most plants. These pots have a hole for drainage at the bottom, and are porous enough so that air can enter their sides. It is well to provide a box on a window-sill to contain the flowerpots. This box hides the pots, and if provided with saucers or a metal tray will catch excess water.

Plants may be put directly into a flowerbox. A flowerbox has the advantage of providing space for more soil, and of being more nearly permanent. It is more difficult to remove plants from a flowerbox than from a pot. The box cannot be moved easily to some other place to provide decorative flowers.

Generally the best place for plants is at window-sill or table-top level. Small shelves in windows or hangers on the sides of windows are generally nuisances. They make it difficult to draw shades or to clean the windows. The plants are not in a convenient place for watering. Pots often used are too small to provide

enough soil to hold water for the plant.

Some method should be provided for sprinkling the foliage of houseplants. Sprinkling removes dust from the leaves, making them more attractive and more able to absorb air. Sprinkling also discourages the growth of red spiders and cottony aphids, both common house plant pests. The best way usually is to have the plants in movable pots, and to carry them to a sink, tub, or to an outdoor space if the temperature is well above freezing.

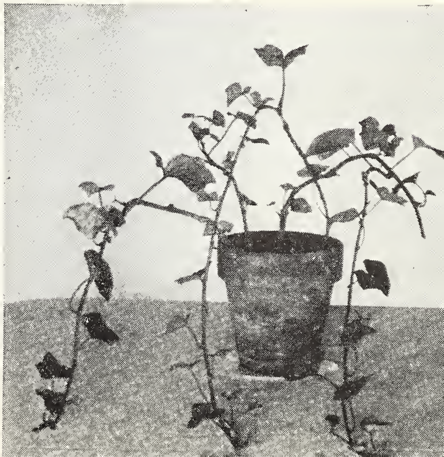
What kinds of plants may we grow? Houseplants may be grouped in several ways. There are the foliage plants and the flowering plants. There are annuals started from seeds each year. There are shade plants and sunny window plants.

The commonest foliage plants are the ivys, the sansevierias, the coleuses, the sedums, the century plant family, and cacti. Ivys are vines or small bushlike plants. They have waxy, green leaves. The sansevieria have thick, bladelike leaves which stand erect, and may have interesting patterns of yellow or white on the green leaf blades. The coleus has a green leaf, with red or yellow borders or spots on the leaf. Sedums have thick, fleshy leaves, rounded and growing on thick watery-looking stems. The century plant family has thick leaves spreading from the base, and occasionally sends up a small flower stalk from the center. Cacti are the familiar thorny desert plants. Foliage plants are perhaps the easiest of all plants to grow.

The commonest of the flowering house plants is the geranium. It has attractive green leaves, sometimes with borders of white, and it bears flowers of red, pink, or white. It is easy to grow, but requires sunlight and plenty of water. If a geranium becomes dry it sheds its leaves. The begonias are also common plants. They have waxy, thick leaves and bear beautiful blossoms, which usually are pink in color. African violets have interesting velvety leaves and bear attractive violet blossoms. The fuschia is a bushlike plant which has waxy leaves and attractive pink flowers.

Other plants sometimes grown are the oleander, the rubber tree, the Jerusalem cherry, and azalea. Ferns grow well in north windows if the air can be kept moist. Ferns die in dry, indoor air.

This English ivy has few and undersized leaves. It was subjected to frequent drying because it is in a four-inch pot and it is also infested with scale insects.



There are many plants which may be grown from bulbs. A bulb is a large specialized bud usually enclosed in scalelike leaves. The bulbs are usually purchased ready to plant. Lilies, narcissuses, and daffodils are the commonly grown bulb plants. They bear beautiful flowers which last but a short time. The narcissus may be grown in a bowl of water, with pebbles provided to support the bulb. Most bulbs should be started in soil in a cool, dark room or basement, and not brought into the light until the leaves appear above the soil. This may take from two to ten weeks, depending on the plant. After bulbs have blossomed, they may be planted in the outdoor garden, let grow all summer and stored over winter to be grown indoors the next spring.

What care do plants need? If you put a plant in good soil, water it regularly, wash its leaves, and provide it with enough light, it should grow well. If it does not grow well, there are many things which may be wrong. It may have scale insects, aphids, or red spiders sucking its juices. The soil may contain thrips, tiny flylike insects which eat roots. The plant may have some kind of fungous disease. Generally if a plant seems unhealthy and does not respond to ordinary care, it is best to throw it away. Most sprays are not entirely safe to use indoors. Sometimes washing a plant in warm soapsuds, and then rinsing it, will remove insect pests.

What useful plants may be grown? Sometimes people arrange a special room in which they grow enough vegetables for table use. This system is not practical for most people. A few plants, such as mint, chives, and parsley may be grown in flowerpots. Mint is used for flavoring tea and other beverages, and for flavoring jelly. Chives and parsley are salad vegetables.

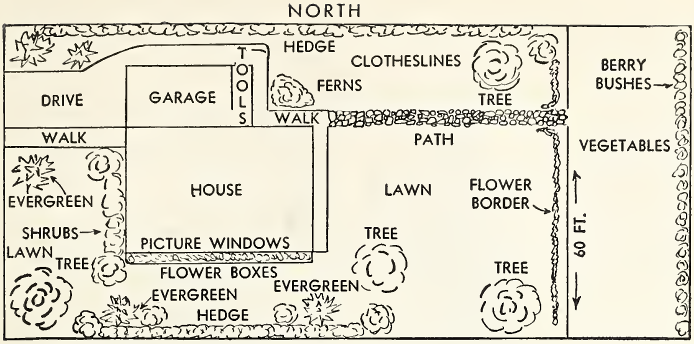
Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

A flowerpot with a heavy glaze might shut out —1— from the soil. If a flowerpot does not provide —2— water remaining in the soil shuts off air from the roots. If a plant grows tall and slender and pale, it probably lacks —3—. Dust and some pests may be removed from leaves by —4—. The ivys and coleuses are considered to be —5— plants. The commonest flowering houseplant is the —6—. It sheds its leaves when it becomes —7—. The growing part of a bulb is a —8—.

3. Can we plan for year-around gardening?

While some people may have only a summer garden, there are opportunities for gardening all year. We can plant bulbs out-



This modern garden plan has many good features. Note that from the front trees frame the house. The picture windows open on an area made cheerful with flower boxes, evergreens for winter, and shrubs. Tall hedges screen the house from the neighbors. Tools are convenient to the backyard. A walk near the north side of the house protects soil from washing away.

doors in early spring or in the fall. We can plant vegetables when it is warmer. We can develop the yard garden in summer. And in late fall and winter we can set up our indoor garden.

Usually the most important part of the garden is the yard planting. The vegetable garden is next in importance. We should develop our garden according to a definite plan. A good plan with a small house on a 60-foot lot is shown in the diagram on this page.

How is a garden planned? To make a plan you apply your knowledge of scale drawing. The easiest way to make a plan is to use graph paper ruled in one-quarter-inch squares. You can use any paper, however, and suit your scale to the size of the paper and of the lot.

It is necessary to measure the lot and the outside of the house, noting the distances from the house to the edges of the lot. The garage, the drive, the clothes posts, and other fixtures must be drawn to scale. Locations of windows and doors should be put in. Trees already growing should be indicated by a circle for the trunk. The area shaded by the tree can be shown by a large, broken ring. You will then draw in any other permanent plants, such as perennial beds, shrubs, and hedges. The diagram shows one method of making a yard plan. Study the plan and the symbols used. Use the same symbols in making your plan. In your plan, the evergreen trees can be indicated by irregular stars.

You can plant quick-growing plants under deciduous trees, for they will grow before the trees leaf out fully. Nothing can be planted in the shade of an evergreen, because it is dense all the year around.

Flower beds may be developed

in clusters of irregular shape. The flower bed is located in such a place that it will if possible have a background of green shrubbery.

In a vegetable-garden plan the individual rows are drawn in, and the name of each vegetable is written in place on each line. Since different vegetables require different amounts of space in which to grow, directions for spacing rows must be taken from the seed package or catalogue.

If you are planning a large farm garden, space the rows to permit use of a tractor-driven or horse-drawn cultivator. While cultivators can be adjusted, leave space for their operation.

What plants should we grow? Before making a list of plants and seeds needed for the garden, know where they will be put, and how many will be needed. Know when to plant. One part of the garden may be used for two crops —an early and a late one.

Many gardeners lack imagination in selecting plants. Too often onions, radishes, lettuce, and peas make up most of the garden. Every year the gardener should experiment with plants which he has never grown before, for both the sake of learning and the pleasure of having new foods on the table.

The planting plan, the seed list, and the garden ground plan must all be worked out together. It is possible to find varieties of the same plant which are planted at different times and which mature at different dates. One variety of radish may be planted in the fall to come up early in the spring. As the radishes come above the ground, peas may be planted between the rows. Other varieties of late radishes may be planted where early lettuce is grown.

There may be several kinds of the same plant, each slightly different and each suited best for some particular situation. There were listed in one seed catalogue 109 varieties of petunias and 18 varieties of radishes. A *variety* is a division of a species. For example, long white radishes belong to a single species, but there may be several varieties which are slightly different in shape, flavor, or date of maturity. Beans are divided into dwarf and climbing varieties. The climbing beans need poles for support.

Catalogues give interesting information about varieties. You should read seed catalogues with the same attitude that you have toward all advertising. They contain two types of material—the sound, tested information useful to gardeners, and the sales statements, which are probably exaggerated.

For the flower garden, sweet peas and California poppies are planted outdoors early in the spring. The marigolds and zinnias must not be planted until the season is advanced beyond the danger of killing frost. Many tender plants are grown indoors and transplanted [dug up and replanted] out of doors when the weather becomes warm enough.

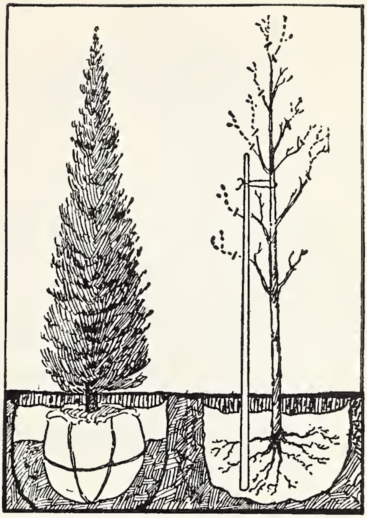
Space in the garden must be left for these plants. They may often be used to replace early-blooming flowers.

For good effect, flowers must be planted with the shorter plants in front and the taller ones in the back. Otherwise the shorter ones are not visible, and the effect of the bed is not one of proper balance. You should read very carefully the statements regarding height of flowers before planning a garden. Helpful information may be obtained from seed catalogues.

What work is done in the fall? The most pleasant work in autumn is harvesting and eating, canning, or freezing the crop. But we must also plan ahead and prepare for the garden next year.

Some plants need more protection than is naturally given. The stalks of peonies may be folded down over the roots, after they have been killed by the first frost. Climbing roses, after the ground is frozen, may be wrapped in burlap. A mound of earth may be built up around the roots of roses to a height of 10 to 12 inches. The stems may be laid on the ground and covered with boards to protect them from being broken. The stems may then be covered with straw or cloth.

The ground, particularly the lawn, should not be covered with leaves or rotted manure in the winter. The decomposition of such materials may kill the grass. It adds little to either the richness of the soil or the protection given the grass roots.



When an evergreen tree is transplanted, a ball of soil is held around its roots. The branches of a deciduous tree are trimmed as indicated by the marks.

Certain diseases of fruit trees are best controlled by spraying when the trees have no leaves. Peach, pear, and cherry trees have diseases caused by fungus plants which grow on the fruit or leaves. Spores of these fungus plants spend the winter on the tree. They may be killed by spraying the bare branches in late fall or early spring.

Of course many insects or weeds may be destroyed best during the fall. Some may be destroyed by spading the ground or by burning infested trimmings. However, it is not possible to trim off the infested parts of all types of plants or to spade in all places. Many insect larvae can be destroyed during the fall by

spraying and dusting the plants with poisons.

The cold frame should be prepared in the fall, since it must be used before the frost is out of the ground. Many kinds of seeds must be sown at that same time. If sown in fall annual plants, such as the pansy and forget-me-not, will come up very early in the spring and be large enough for transplanting as soon as the ground is ready. Perennials also may be sown in the fall. They will not germinate until spring, but when the right time comes they will be where they can start.

It is wise to have the soil ready that may be needed for potting plants during the winter and to get a supply moved in before the ground freezes.

Deciduous shrubs and trees may be moved late in October when the leaves have fallen and the sap has had time to flow back into the roots. Early spring planting, before the leaves begin to show, is as good or better than fall planting in most sections. Usually it is advisable in transplanting deciduous plants to trim off about one-third of their branches. Then most of the growth, when it starts again, will repair damage and enlarge the root system. Many plants are actually improved by repeated transplantings. While evergreens may be moved any time of the year by wrapping a large ball of earth about the roots so that their natural location is not disturbed, they are readily transplanted during the period just after the ground freezes.

Many shrubs and vines may be trimmed back in the autumn. A few should be trimmed almost to the ground, for each year they start new branches on which flowers or fruit form. Other shrubs may be trimmed back considerably. But some shrubs blossom from wood grown the previous summer, and if these are trimmed they will have few blossoms. Fruit trees must be trimmed, or pruned, when the sap is not flowing. Pruning thins the branches and provides light for the leaves, shapes the tree as desired, and removes unproductive branches.

Things to think about

Match the following subjects and predicates. Copy the sentences in your notebook.

Subjects

1. A garden plan
2. A variety
3. Seeds of perennial flowers
4. Roots of plants
5. Straight lines on a plan
6. Tall flowers
7. Seeds of sweet peas
8. Seeds of marigolds
9. Burning trash in the fall
10. When trees are not growing, they

Predicates

A. are injured by alternate freezing and thawing.

B. is best made on a piece of graph paper.

C. should be planted in the back of the bed.

Swift and Company

A corn plant can show its need for minerals as indicated in this table:

APPEARANCE	INDICATES LACK OF
Yellowish-green leaves, stunted	Nitrogen
Tips of leaves gummed together	Calcium
Purple color in leaves	Phosphorus
Bottom leaves dead, yellow stripes between veins of upper leaves	Zinc
Scorching along edges of leaves	Potash
Regular yellowish-white stripes on leaves	Magnesium

D. is a subdivision of a species.
E. may be planted in the fall.
F. can be planted in the early spring.
G. cannot be planted till danger from frost is past in the spring.
H. may be used to indicate rows.
I. may safely be pruned.
J. may kill some insects and plant diseases.

4. How is soil prepared?

The success of your garden depends in part upon the soil. If the soil is good, it need only be prepared for the seeds and cultivated. If it is poor, either you can try to find plants which will grow in poor soil or you can improve the soil by use of fertilizer.

Of what is soil composed? Soil is composed of finely divided particles of rocks mixed with humus [hū′mŭs, partly decayed vegetable matter]. The space between the particles is filled with air, and each particle is covered with a thin film of water.

The rock particles may be divided into three groups according to size. The largest particles are called sand; the smallest,

clay; and those intermediate in size, silt. A soil containing a fair proportion of each of these materials is called loam. A soil which is said to be sandy has a large proportion of sand. A clay soil has a large proportion of clay. Soil which is sandy tends to lose its moisture but warms up quickly in the spring. For this reason it can be planted earlier than can a clay soil. Clay holds water well, but dries on the surface and becomes hard, often shrinking until large cracks appear.

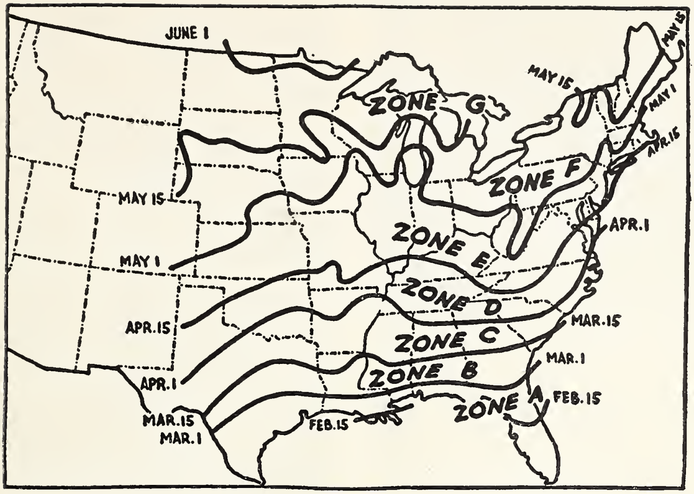
The humus present in the soil gives it a black color. It acts as a sponge to help the soil hold larger amounts of water. Composed of decaying plant and animal matter, it contains large amounts of the minerals needed by the plants. Certain bacteria in the soil make available mineral matter by insuring the decay of plants and animals. Still other bacteria take nitrogen from the air and convert it into soil minerals. These are then dissolved in the water which is taken in by the plant roots. Nitrogen compounds in soil are absolutely necessary for plant growth.

How is soil prepared for planting? To permit the roots to grow deeply, the soil must be thoroughly broken up by plowing or spading. The method used in plowing or spading should result in bringing the lower soil to the surface. In order to do this with a spade, each spadeful of soil should be turned over so that the topsoil falls into the hole formed by removing the soil. If the soil tends to cling together, it may be thoroughly broken with the spade and raked to produce fine particles.

Spading may be done either in the spring or in the fall. If the ground contains many grubs or other insect larvae, fall spading will loosen them from their burrows so that they will be destroyed by the winter freezing. A soil that tends to be lumpy will be broken by freezing. Fall spading opens spaces in the ground that permit water to seep through and carry away valuable chemicals during the spring before the plants have a chance to get started. Therefore, spring spading is usually more satisfactory for the home garden.

How can soil be made more fertile? Fertile soil contains the proper kinds and amounts of minerals needed by plants. The important elements needed are nitrogen, phosphorus [fŏs′fō·rŭs], and potassium [pō·tăs′ĭ·ŭm]. As the soil is used year after year, plants gradually remove these elements so that more needs to be added from time to time. The soil may become acid [sour] because of the decay of plant materials. Chemicals such as lime may be added to neutralize the acid and make the soil "sweet." Adding these necessary minerals to the soil is called fertilization.

Manure is a fertilizer. There are also commercial preparations which may be bought. Manure has the advantage of being cheaper, but it does not supply all the necessary minerals. Com-



"Better Homes and Gardens"

The most probable date of the last killing frost is shown on this map prepared by the U. S. Department of Agriculture. This map does not guarantee that there will be no killing frosts after these dates, however.

mercial fertilizers do not increase the amount of humus as does manure, but they may be obtained in many different combinations to provide the desired proportions of minerals. Commercial fertilizers are impure chemical compounds, usually mixed with some type of inactive material. If the soil can be tested, special fertilizers can be made to give exactly the type of soil which is needed. State departments of agriculture or local county agricultural agents will help you test your soil and prepare the proper mixture of fertilizer.

In general, it is good practice to collect grass trimmings and leaves and preserve them to increase the amount of humus in the soil. You can put them into a hole and from time to time wet them down until they decompose rather thoroughly. As the materials collect, soil should be added in layers. The mixture may be used in seed flats, in cold frames, or in the garden where a rich soil is desired. Many of the minerals needed by plants are available in leaves and trimmings. Decomposed vegetable matter prepared in this way is called compost.

A poorly drained soil may become acid and will not provide air for the roots. Some soil may be worth draining by use of a tile drain or an open trench. A trench filled with broken stone, rubbish, and sand sometimes will drain land satisfactorily.

How can different crops aid in maintaining the soil? Some plants remove one combination of minerals and conserve [save

for use] others, while other plants do exactly the opposite. Instead of growing the same kind of vegetables year after year in the same part of the garden, it is better to change them around in successive years. A part of the yard may be used for a clover lawn for a few years, then used for a garden while the old garden becomes lawn. Changing crops from year to year is called rotation of crops. On farms it is a practical way of avoiding some of the cost of commercial fertilizer.

Sometimes in vegetable gardens it may seem more desirable to have certain plants in certain places. Sweet corn, which grows much taller than other garden plants, is not desirable in the first rows of the garden. However, to replant sweet corn year after year in the same position will result in removing those elements necessary for its growth.

Root vegetables, in general, use the same type of minerals. Therefore, an area in which beets or carrots have been raised one year should be followed by leafy vegetables during a succeeding year. Tomatoes, which take a still different combination of minerals from the soil, should be moved each year. Careful planting in the garden maintains the soil for the best results.

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

The decayed plant material in soil is called —1—. The two main steps in the preparation of the soil are —2— and —3—. Raising different kinds of crops on the same area in different years is known as —4— of crops. The smallest particles in a soil are called —5—, and the largest are called —6—. A —7— soil is called a heavy soil because it is hard to work. A soil containing a mixture of sand, silt, and clay is called —8—. A —9— soil warms up quickly in the spring. Acid soils may be made "sweet" by adding —10—.

5. How do we start the plants?

The germination [growth] of seeds depends upon proper conditions of moisture and temperature. Young plants may not be able to withstand extreme cold or too much rainfall. They may die because of lack of oxygen in wet soil. Consequently it is quite important that we do not attempt to start plants until the season has advanced far enough for them. Planting guides provided by seed houses and nurseries are very helpful in this respect, although dates given in most of these guides must be corrected for the latitude in which you live. Also the seeds must be planted at the correct depth so that the seedlings will be able to push through to the surface before their supply of food is exhausted.

When should seeds be planted outdoors? The earliest time of planting seeds outdoors depends upon the date of the last killing frost for your own region. Seed companies generally provide information regarding this date for their customers. It is based on records of the United States Weather Bureau.

The hardy plants can be planted from three to four weeks before the date of the last killing frost, but the seeds of the tender plants must not be put into the ground until this date. Radishes, beets, peas, and carrots are generally considered to be hardy plants, while beans, corn, peppers, eggplant, squash, melons, tomatoes, and cucumbers will be killed by freezing temperature. The tender plants should be planted when the average soil temperature at the depth of planting is 55 to 60 degrees.

If successive plantings are to be made, it is equally important to know the date of the last killing frost. To have sweet corn ripening so that it can be used throughout the growing season, some is planted about every 10 to 14 days, until it will no longer have enough time to ripen before the first killing frost of the fall. You can obtain from the seed producer the information about the time needed for a variety of corn to mature. If you have a 92-day corn, this number subtracted from the date of the first killing frost in autumn gives the last planting date.

U.S.D.A.

The most common method of planting seeds is to drop them into an open furrow which is then filled with earth. The earth is tamped firmly above the seeds. Depth of planting is on the package.

It is not possible to provide a succession of all vegetables because some will not grow well during hot, dry weather. Radishes usually grow too rapidly in hot weather to fill out the root properly. Other vegetables, such as parsnips, require the whole growing season to mature and therefore can be planted only once each season.

How can we start plants earlier? Since the earliest vegetables of the season are worth more money, gardeners frequently start their plants indoors in shallow boxes, called flats. These boxes, approximately 1 foot wide and of varying length, are filled with good soil and fertilizer during the fall. Often a layer of cinders or pebbles is placed in the bottom of the box to permit the roots to get plenty of air and to provide a place for excess water.

Many seeds will germinate indoors in such boxes when they are placed in sunny windows. In order for tomatoes and cabbages to mature in the northern states, they must be started indoors. Tomato plants are best transplanted when six to eight weeks old.

After the seedlings are large enough and the date of the last killing frost is past, they can be transplanted. By removing the weaker seedlings, only the stronger plants are given a chance to grow in the garden. Transplanting also helps many plants by increasing the amount of root growth. (See page 443.)

Another method of starting plants earlier is by the use of the cold frame. It consists of a box without a bottom which is sunk in the ground. The top slopes, its south side being lower than its north side. The top consists of a cover made of glass set in a wooden frame. As the sun's rays pass through the glass, they strike the soil and heat it. Since the air is confined, the heat is held within the box to keep the germinating seeds warm during cool nights and safe from killing frost. Cold frames will work quite well providing two or three days without sunshine do not occur. Because of this possibility, seeds cannot be started quite so early in cold frames as in flats.

Hotbeds are also used to obtain earlier crops. The hotbed is about the same as the cold frame except that the bottom of the bed is filled with manure, which provides heat as decay sets in after the first warm sunshine has started the action in the spring. The seeds are planted in a layer of soil on top of the manure.

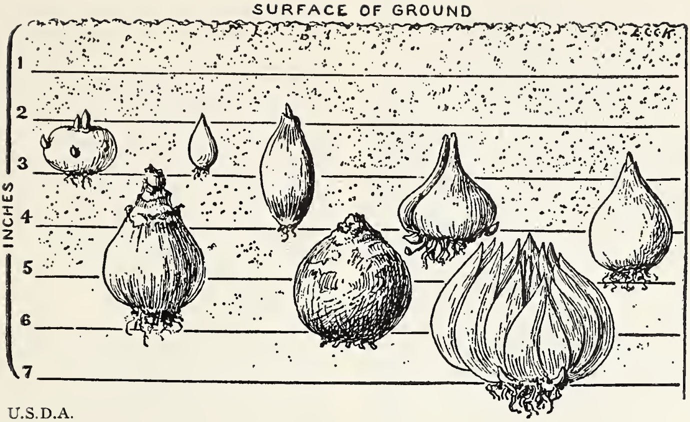
Another kind of hotbed is warmed by an electric heating unit beneath the soil. This consists of an insulated cable containing resistance wire, which is buried a few inches below the surface of the soil or hung on the frame around the edge of the box. A hotbed 6 feet square requires about 60 feet of cable and about 400 watts of electric current under average conditions.

Seeds may be started very early in hotbeds. Often gardeners use large numbers of them to produce the whole crop since the plants may be too large for transplanting by the time the danger of frost is past.

Perhaps the best way to get early plants for the average school garden is by the use of the seed flats.

How should the seeds be planted? The distance between the rows should be much greater than the space between the plants in the row, since it is usually necessary to allow sufficient room for a person to work between the rows. Plants such as tomatoes need about as much room within the row as they do between the rows. Seeds such as those of peas are scattered close together in shallow trenches, called drills, and covered.

The depth at which the seeds are planted is of considerable importance. In general, large seeds are planted deeper than small



U.S.D.A.

The depth for planting a bulb is about three times the height of the bulb. The depth is measured from the bottom of the furrow.

seeds. The rule is that the depth should be about two or three times the diameter of the seed. However, the depth can vary, depending upon the kind of soil and the season. Seeds can be planted deeper in sandy soils than in clay soils, since it is easier for the shoots to force their way to the surface. If the seeds are planted during the summer when the soil is usually dry at the surface, they should be placed slightly deeper than they would be in the spring.

The table shows how to plant seeds. The date is for the climate typical of New York.

How do the seeds germinate? After the seeds are planted, we must wait a week or longer before they germinate. The embryo within the seed first absorbs water and increases in size. Then the seed coat splits, and the root starts to grow downward. Next the shoot appears and begins to grow upward, developing leaves as it grows. No matter in what position the seed is planted, the root always grows down and the stem always grows up. The

NAME	DATE TO PLANT	DEPTH TO PLANT	ROWS APART	PLANTS APART	TIME TO MATURE
Radishes	April 15	½ inch	1 foot	1– 2 inches	20– 40 days
Lettuce	April 15	¼ inch	1 foot	4– 6 inches	60– 90 days
Onions (sets)	April 15	2 inches	1½ feet	3 inches	90–120 days
Peas	April 15	3 inches	2½ feet	1 inch	40– 80 days
Beets	April 15	1 inch	1 foot	3– 4 inches	60– 80 days
Carrots	April 15	½ inch	1½ feet	2– 3 inches	75–110 days
Turnips	April 15	½ inch	1½ feet	3– 4 inches	60– 80 days
Corn	May 1	2–3 inches	2½ feet	30–36 inches	60–100 days
Beans (bush)	May 1	2–3 inches	1½ feet	2– 3 inches	40– 65 days
Tomatoes	May 20	....	3 feet	36 inches	100–140 days

strange thing is that the force of gravity affects growth both up and down.

DEMONSTRATION:
HOW DO SEEDS GERMINATE?

What to use: Glass tumbler, soil, blotting paper, seeds of radishes and peas.

What to do: Fit a piece of blotting paper inside the tumbler. Fill with soil. Between the blotting paper and the tumbler push a few seeds of soaked peas and radishes. Put the tumbler in a warm place and keep the soil moist.

What was observed: What part of the seed begins to grow first? In what direction does it grow? What appears next? In what direction does it grow?

What was learned: State briefly what happened to the seed.

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

The —1— of planting a seed depends on its size. The distance apart of planting seeds depends on the —2— of the mature plant. Seeds of —3— plants can be planted several weeks before the date of the last killing frost. Those plants whose seeds cannot be planted till the time of the last killing frost are said to be —4—. A box set on the ground and provided with manure below the surface of the soil is called a —5—. A box without the manure is called a —6—. Seeds like peas, which are sown close together, are planted in —7—. The force which helps the roots of seedlings to grow down and the stems to grow up is —8—. The proper depth for planting carrot seeds and turnip seeds is about —9— inch. The proper depth for planting peas is about —10— inches.

6. What care does a garden need?

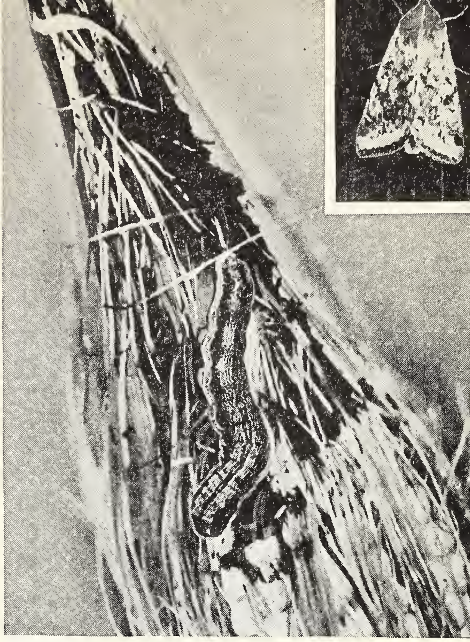
Perhaps nowhere can we observe more clearly the continuous struggle for existence which takes place among living things than in the garden. The same plants which man eats are equally attractive to insects. Also, the ideal conditions which we create for the growing things of our garden are equally good for many undesirable plants. To obtain the best results, we must be able to recognize these garden enemies and find out how to control them.

How are plants affected by water in the soil? Plants absorb more water from the soil than they actually need to carry on the process of making sugar. A single corn plant gives off about 50 gallons of water during the growing season. This water is absorbed by the root hairs and passes up through the stem to the leaves, carrying with it the necessary minerals. Some of the water is used in the sugar-making process but by far the larger part evaporates, passing out through the stomates of the leaf. The water which the root hairs absorb is that held in a thin film on the surface of the soil particles. Such

water is called capillary [kăp′ĭ·lĕr′ĭ] water.

Roots cannot live in soil which contains large amounts of free water between the particles. Such water forces out the air which roots must have. The water which is attracted to the surface of the soil particles rises through tubelike spaces in the soil, just as kerosene rises through the tubes of a wick. The process by which water rises against the force of gravity is known as capillarity [kăp′ĭ·lăr′ĭ·tĭ]. If the soil is left undisturbed, the water will rise to the surface and evaporate, thus removing it as a source of supply for plant roots. However, if the top layer of soil is broken up into fine particles, the tiny tubelike spaces will be destroyed and the water will not reach the surface. Thus less water evaporates and more is retained in the soil for the use of the plants. This loose layer of soil is called a mulch. Frequent hoeing of the garden will produce a good mulch and conserve the moisture of the soil.

In spite of the mulch, during dry seasons the ground may not contain sufficient water. To provide for this the garden must be irrigated. Furrow irrigation, that is, running water in ditches between rows, has some advantages over sprinkling. It permits better control of the amount of water applied, and does not sprout so many weed seeds nor crust so much of the soil. Water running in furrows does not wash spray from plants. Sprinkling requires somewhat less attention than



U.S.D.A.

The corn ear worm is the larva of the moth shown in the inset. It destroys part of the corn and makes the rest unattractive for use as food.

does furrow irrigation, and is the only practical method where the land is not fairly level. After the garden is irrigated by either method, the soil should be examined to see if it is actually wet enough. As soon as the soil dries enough, the crust which forms should be broken by shallow cultivation.

Irrigation is absolutely essential in many parts of the West. In the South and in parts of the Central states there may be a period of a few weeks of dry, hot weather in summer. Irrigation for this brief period has been found to increase yield from two to four times. Many large-scale gardeners

and farmers in these regions are now providing part-time irrigation. Need for irrigation water provides another reason for water-control in rivers.

Small gardens need water also. A common hose may be used, but plenty of water should be applied. If only the top layer is watered, the roots will tend to grow toward the surface, which of course leaves them in the driest part of the soil.

Frequent hoeing also helps to mix air into the soil. Thus we see that there is a very close relation between the water and air in the soil and the cultivation of the garden.

How are plants affected by garden insects? Because many garden plants are not particularly bothered by insects, gardeners frequently neglect to take any steps to free their gardens of these pests. Radishes, beets, and lettuce are usually somewhat free from insects, but the other plants are often attacked. For this reason some method of controlling insects should be used.

The common garden pests may eat the leaves of plants, cut off the stems of young plants, or eat the roots of plants.

How can we control insects? If you can see small insects on the twigs and leaves of a plant in your garden, you may be sure that they are after food. Although a few kinds of insects are helpful, you may safely destroy those you see on your plants. Generally the easiest and the most effective method consists of spraying the plants with a poison.

Two poisons sometimes used for chewing insects are Paris green and lead arsenate. To make up small amounts, two tablespoonfuls of the poison are used for four gallons of water. Small hand sprayers, which may be bought at low cost, are satisfactory to distribute the poison. Several applications at intervals may be necessary to destroy these insects.

If the insects are on vegetables whose seeds or tops are used for food, it is dangerous to apply such poisons because they may not be completely removed in preparing the food for the table. However, the most common insects found on leaves of vegetables are potato beetles, cucumber beetles, and certain caterpillars. About the best way to remove the potato beetle and the caterpillar is by knocking them off the plant into water in a shallow pan by striking the plant with a stick.

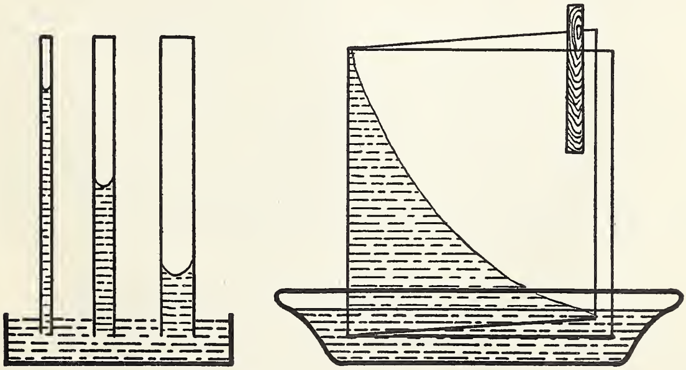
Several new chemicals, DDT, 1068, and others are safely used to control garden insect pests. These chemicals are either applied in water as a spray or dusted on in powder form. They remain on the plant for some time, and kill many insects with which they come in contact. It is well to spray tree trimmings and weed piles with a water solution of one of these chemicals to keep insects from growing in these wastes. For killing many insects a chemical called rotenone is used. This is applied as a dust to plants and is not poisonous.

It should be used for spraying leafy vegetables which might carry poison to the table.

Gardeners sometimes obtain a crop by planting a large number of seeds close together with the hope that the insects will not eat all the plants. After the plants are safely through the ground, they are thinned out so that only three or four are left in one group.

If plants are found cut off at or near the ground, you can be sure that the ground is infested with cutworms. Other plants which seem to break or wilt above a certain point have probably been attacked by stalk borers. Grasshoppers also eat the stems of plants.

The cutworm is the larva of a moth which lays her eggs on plants near the ground. The cutworm burrows just below the surface and comes out at night to feed upon such plants as tomatoes and corn. Very often the larvae can be turned up by hoeing close to the plant and near the surface. One way to get rid of both cutworms and grasshoppers is by the use of poison bran. This is prepared by mixing a half teaspoonful of Paris green with one quart of bran and adding to it a separate mixture containing one-fourth cupful of molasses or brown sugar and one and one-half cupfuls of water. If this poison is scattered over the ground around the seed beds or plants in the evening, most of the cutworms will be destroyed by morning. Some poisons used to kill cutworms are in liquid form. This liquid, when poured into holes in the soil, evaporates and the poison gas kills the cutworms. Tomato plants may be easily protected from the cutworm. When young plants are set out, the stem may be wrapped with a piece of paper and sunk a little below the ground so that it extends a little above the surface.



These tubes and glass plates are used in the demonstration to illustrate the principle of capillarity.

The stem borers are very difficult to eliminate. Since they develop in trash, they can be controlled by carefully burning all trash each fall and spring.

What other care does the garden require? It is impossible for plants to develop properly unless they are thinned when they first come up. Crowding could be prevented by scattering the seed, but many seeds are so small that they are difficult to separate. It is usually easier to let the seedlings come up and then remove the weaker plants. In thinning plants care should be taken that neighboring plants are not disturbed.

DEMONSTRATION: WHAT IS THE PROCESS OF CAPILLARITY?

What to use: Two pieces of glass, each about three inches square, rubber band, match, plate, glass tumbler.

What to do: Put the two pieces of glass side by side. At one edge insert a match between them. This separates the pieces of glass to form a V-shaped space. Put a rubber band around the the pieces of glass to hold them together. Pour some water in a plate. In the plate put a tumbler. Stand the pieces of glass on edge, leaning against the tumbler, with the match at one side.

What was observed: Note the height to which the water rises between the pieces of glass. What sort of line does the surface of water make? Where does the water rise the higher, at the point where the pieces of glass are closest together or where they are farthest apart?

What was learned: Where would the water rise the higher, in a soil with small spaces between the soil particles or in one with large spaces between the particles?

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

The process by which water rises through the soil is called —1—. A loose layer of soil made by hoeing is called a —2—. The cutworm is the —3— of a moth. Paris green may be used to poison —4— insects. Strips of paper may be used to protect young tomato plants from —5—. The parts of roots that absorb water from the soil are the —6—. The holes in the skin of a leaf through which water and air pass are called —7—. Hoeing the garden helps to keep —8— in the soil. One value of hoeing, especially in clay soils, is that it mixes —9— with the soil. One way of controlling cutworms and grasshoppers is to scatter poisoned —10— over the ground.

7. How can weeds be controlled?

Many plants which are called weeds may actually be useful plants, but when they are found out of place they are undesirable. Real weeds are very successful plants because they are able to grow almost everywhere. Many of them grow especially well in

gardens. We must understand the harm they do and be able to control them.

What are weeds? Weeds are not easy to define. Such plants as the thistle, burdock, and poison ivy are certainly undesirable plants and are considered to be weeds. However, corn growing in an oat field is a weed, if we think of it as a plant growing out of place. The great majority of weeds have no value in themselves and generally are more hardy than are the cultivated plants.

In general, weeds are sown wherever man has gone. Explorers who have visited remote places report that none of the weeds common to civilized areas are ever seen. The seeds of many weeds stick to clothing or animals, or become mixed with the grain and feed which man carries with him for his livestock to eat. Many of the weeds in the United States have been introduced from Europe and are found in much greater numbers in the regions where people have settled than in the open country.

Weeds, like other plants, may be classified on the basis of their growth habits. Some are annual; some are biennial; and some are perennial. The annual plants produce large numbers of seeds, and are usually well equipped to scatter them widely. It is not uncommon for a single annual weed to bear tens of thousands of seeds. Indeed it has been estimated that some plants may bear as many as a million seeds.

Wheeler, Reynolds and Stauffer

This is a device which can be used to kill resistant weeds by putting chemicals in the soil.

Biennial weeds are less common than the annuals but are equally hardy. Such plants as burdock, wild carrot, and sweet clover produce their seeds during the second year of their growth.

The perennial weeds are also common, and because of their ability to reproduce by means of underground stems and roots they are difficult to destroy.

Why are weeds able to survive? Even though you take good care of your garden year after year, certain weeds continue to come up. If these plants came from seeds of last year's weeds, they

would have been destroyed by cultivation. Obviously these weeds come from seeds which were deposited years before and were later buried by successive spadings too deep to germinate. During all this time the seeds remain alive so that when the garden is spaded again some of the buried seeds are brought up near the surface where they have a chance to germinate.

Seeds of pigweed and foxtail may live as long as 25 years. Some weed seeds have been known to live more than 50 years. Therefore if the weeds are allowed to go to seed for just one year, they may remain in the soil and cause trouble for many years thereafter. Many weed seeds do not germinate the first year even under ideal conditions, but are protected for some time by hard seed coats.

The ability to produce seeds with unusual qualities is only one factor in determining the success of a plant. The plant itself must be able to withstand difficult conditions. It is believed that plants which have been cultivated and protected for many generations have lost in part the ability to compete successfully with other plants.

In order for a plant to survive it should have certain characteristics. A plant which can grow rapidly in a limited space and obtain its share of minerals is able to meet competition successfully. However, if it has the ability to withstand shade, most plant diseases, insect pests, and extreme periods of dryness and moisture, it will probably come out ahead in the struggle for existence. Besides these characteristics, some plants are able to maintain themselves in poor soil and still provide themselves with protective adaptations. Few plants have all these powers, but many weeds have combinations of three or four.

Why must we destroy weeds? Weeds have the same needs as do other plants. They absorb water through their roots, and take their share of minerals. Their leaves need sunlight. All plants growing close together compete for the same things. As a result, the garden plants may be partially or completely crowded out by weeds and the gardener who neglects to destroy or keep down the weeds does not get a large yield.

Perhaps one of the most serious effects on common plants is the reduction of water supply, which occurs because most weeds have strong, vigorous roots. It has been shown that many weeds consume as much water as an ordinary corn plant.

Some weeds, such as the dodder, are parasites [organisms which live on other organisms] on plants and rob their host of much of the food which it produces. Another kind of damage done by the weeds results in grain crops of lower quality. Many weeds mature at the same time as the crops. When the grain is separated by threshing, the seeds of the weeds are also

E. I. du Pont Nemours and Company

The strip in this field which shows no white flowers was sprayed with 2,4-D. The flowers are blossoms of weeds.

separated and mixed with the grain. Such grain has a low market value and should never be used for seed.

Many weeds are injurious to animals as well as to plants. Wild barley seeds may produce serious irritation on the skins of animals. These sores may cause death, or infections which result in death. Some weeds actually contain enough poison to kill cattle or sheep. In the western states the locoweed kills many sheep, horses, and cattle which eat it. Some weeds when eaten by cows impart an unpleasant taste to the milk and butter. Many people are sensitive to poison ivy, although some people do not seem to be poisoned by it. Poison ivy is really easy to identify, since the leaflets are arranged in threes. While poisoning by this weed is not fatal, it may be exceedingly unpleasant. The poison is an oil produced by the plant.

How can we control weeds? All plants can be killed by preventing their shoots from reaching the sunlight where they will be able to manufacture food. Seedlings of weeds which are brought to the surface before the tiny plant has had opportunity to grow will dry out and die. Therefore it is quite important to hoe and rake the ground thoroughly at the time when the conditions are ideal for germination of the seeds. Even though no weeds are in sight, it will pay to rake and hoe the garden thoroughly.

In cultivation of corn and garden plants it is important not

to injure the roots of the plants. When the plants are small their roots do not extend far from the plants, but as they increase in size the roots spread in all directions near the surface of the soil. Deep cultivation of older plants will seriously weaken them.

Where patches of weeds have already been able to develop, they can be removed by continuous cultivation. Farmers who have plowed quack grass patches repeatedly throughout the growing season for a year or two have been able to destroy the weed.

Chemical sprays are useful in getting rid of weeds which resist cultivation, or which grow where they cannot be cultivated. Lawn weeds may be killed with a chemical called 2,4-D which kills dandelions, plantain, and other broad-leaf plants but not the grass. It does kill clover and flowers, however. This 2,4-D will also kill poison ivy. Several other weed-killing chemicals may be bought at the garden-supply store.

Perhaps one of the greatest aids in the destruction of weeds are the birds. Examination of the food found in the crops of many birds shows that weed seeds make up a part of their food. While some of the seeds are not digested and are therefore scattered by the birds, the great majority of those eaten are destroyed.

Things to think about

Copy the following paragraph in your notebook. Complete the sentences.

The best way to control weeds is to —1— the garden. A single weed plant often bears thousands of —2—. Weed —3— may live for many years without germinating. Weeds may cause a —4— in the yield of crops. Some weeds are —5— to touch. One way to control weeds is by —6— of crops. Weed seeds are eaten by many —7—. Any plant which takes food from another living organism is a —8—.

A review of the chapter

The opportunity of watching plants develop is available to all through the use of small gardens which, if desired, may be planned to provide quantities of flowers or vegetables for use or sale. Gardens, either formal or informal, may be used for many purposes in the typical house yard. Large numbers of annual and perennial plants with their many varieties make it possible for each individual to plan the garden which he likes best.

Certain rules have been developed which are helpful in planning. Many plants require certain conditions for best development. Soil must be properly prepared and maintained; seeds must be planted in a manner which will enable

them to get a good start; and the young plants must be protected from the common garden enemies, insects and weeds. Finally, cultivated plants must be protected against the severe disturbances of winter. Much of the garden work can be done in the fall.

Many kinds of beautiful and useful plants may be grown indoors. A reasonable amount of study will enable the average student to learn the methods of indoor gardening.

A garden illustrates very well the conditions under which living things grow. We learn that the soil provides materials needed for growth of plants. Plants in turn provide food which is used by animals, including insects and man. Some organisms, in taking food for themselves, cause diseases in plants. Living things compete for food, water, light, and space in which to grow. Weeds are more successful in competition than are most cultivated plants.

Burning trimmings and garden wastes is a pleasant task. A burner of the right sort will prevent burning the soil, will make the fire easier to control, and will increase speed of burning.

Word list for study

Be sure that you can pronounce, spell, define, and use in a sentence every word in this list. Each of these words has been defined or explained and used in this chapter.

deciduous	perennial	annuals
annual	biennial	fertilizer
aphid	bulb	cutting
scale insect	fungus	variety
thrip	species	transplanted
cold frame	hot bed	prune
humus	phosphorus	potassium
nitrogen	compost	germination
capillary	irrigation	weed
competition	cultivation	

An exercise in thinking

Below are two groups of sentences. The first group contains principles, which are large general ideas. Each sentence in the second group contains an idea related in some way to one of the principles in the first group. Write the numbers from 1 to 32 on a piece of paper or in your notebook. Find the principle which best explains the idea in the second list. Then after the number on your paper write the letters before the related principle.

List of principles

A. Water, mineral foods, heat, light, carbon dioxide, and oxygen in right amounts are necessary for the growth of plants.

B. All animals are dependent upon green plants for food.

C. There is competition among living things for food, water, light, and living space.

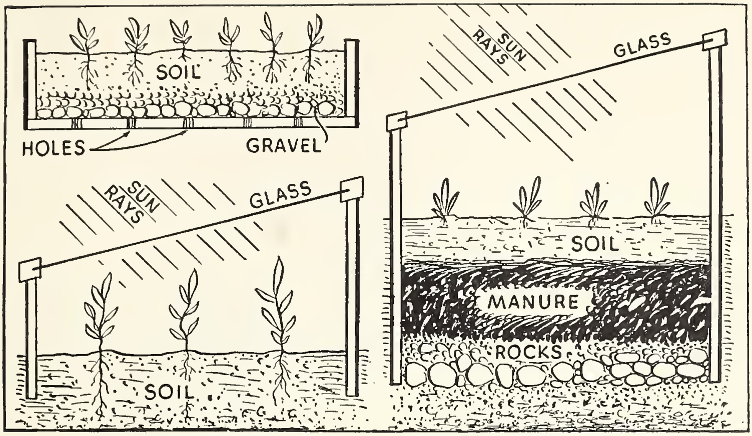
D. Bacteria and other fungi, in getting food for themselves, cause decay and plant and animal diseases.

E. Each type of plant has its own rate of growth and is best adapted to a particular kind of environment.

F. Attractive arrangement of plants does not necessarily provide best conditions for their growth.

List of related ideas

1. Flowers look better against the house wall but grow better in open spaces.
2. Flowers and shrubs shoud not be planted in the center of the lawn.
3. The garden should be fertilized.
4. A garden plan can be made on a piece of paper.
5. Cucumber plants should be planted farther apart than corn plants.
6. Before planting seeds, one should spade or plow the garden.
7. Weeds cause a decrease in the yield of crops.
8. Vegetation plowed into the soil decays and improves the soil.
9. Short shrubs should be planted in front of tall shrubs.
10. Biennials produce seeds the second year.
11. To get flowers the first part of the season, perennials should be raised.
12. The garden may need protection from insects.
13. Clover requires sweet soil.
14. Plants in the center of a flower bed often have few leaves along the stem.
15. Seeds should be planted far enough apart to allow room for growth.
16. Blueberries require an acid soil.
17. Insects do much damage in the garden.
18. Hoeing the garden helps keep moisture in the soil.
19. Spores of microscopic plants may be killed by winter spraying of fruit trees.
20. Flower gardens do not grow beneath evergreen trees.
21. Because morning-glories are climbing plants, they require supports on which to grow.
22. The distance between seeds at planting depends on the size of the mature plant.
23. A gray, slimy appearance of the



Read the text on page 430 to identify the seed flat, the cold frame, and the hot bed.

wilting leaf of a rose may indicate a mildew.

24. The cutworm is especially harmful to young plants.
25. Hoeing the garden mixes air with the soil.
26. Radishes mature and go to seed in one summer.
27. Dandelions may crowd out the grass of a lawn.
28. Many birds eat weed seeds.
29. During wet seasons clay soils do not provide enough air for the roots.
30. In the North some varieties of roses need to be covered for the winter.
31. Branches do not develop fully on the side of a tree next to the house.
32. Planting flowers and shrubs in masses gives pleasing effects.

Some things to explain

1. Why are insects more dangerous to gardens than rabbits are?
2. Why do many people fail to grow vegetables even where ground is available?
3. What is the commercial value of flowers?
4. Is it true that trees attract birds which eat only the insects attracted by the trees?
5. Why do many city dwellers prefer to live in apartments?
6. Do seed catalogs make unfounded claims?

Some good books to read

Balthis, F. K., *Plants in the Home*
Bates, A., *Gardener's First Year*
Dempsey, P. W., *Grow Your Own Vegetables*
McKenny, M., *Book of Garden Flowers*
National Recreation Association, *Gardening; School, Community, Home*
Spencer, E. R., *Just Weeds*
Teidjens, V. A., *Vegetable Encyclopedia and Gardener's Guide*

Film List

Introduction

MOTION PICTURE FILMS

Science and Superstition. Coronet Instructional Films

FILMSTRIPS

Thomas Alva Edison. GE
Louis Pasteur. Metropolitan Life Insurance Co.

Chapter 1. Energy in Everyday Living

MOTION PICTURE FILMS

Nature of Energy. Coronet Instructional Films
Ears and Hearing. Encyclopedia Britannica Films Inc.
Fire. Encyclopedia Britannica Films Inc.
Distributing Heat Energy. Encyclopedia Britannica Films Inc.
A Word to the Wise. National Retailers Mutual Insurance

FILMSTRIPS

Prevent Farm Fires. USDA

Chapter 2. Work in Everyday Living

MOTION PICTURE FILMS

How We Get Our Power. Young America Films Inc.
Light and Power. Films Inc.
Turning Point. Castle
Airplanes. U. S. Bureau of Mines
Conquest of the Air. Films Inc.

Simple Machines. Encyclopedia Britannica Films Inc.
Story of Electricity. Knowledge Builders
Magnets. Young America Films Inc.
Flow of Electricity. Young America Films Inc.

Chapter 3. Safeguarding Community Health

MOTION PICTURE FILMS

Milk As You Like It. Dairy Council of St. Louis
The Dairy Industry. Mahnke
Sanitation and the Rural Home. National Motion Picture Co.
Immunization. Encyclopedia Britannica Films Inc.
Men of Medicine. March of Time
Defending the City's Health. Encyclopedia Britannica Films Inc.
Safety in the Home. Encyclopedia Britannica Films Inc.

FILMSTRIPS

How Plants and Animals Cause Disease. Eye Gate
Safe Food and Good Health. Castle
TB Facts. National TB Association

Chapter 4. Providing Pure Water

MOTION PICTURE FILMS

Ground Water. Encyclopedia Britannica Films Inc.
City Water Supply. Encyclopedia Britannica Films Inc.
Clean Water. General Electric

FILMSTRIPS

Farm Water Supply. USDA
Running Water for the Farm. USDA
Ground Water. SVE

Chapter 5. Our Earth in the Solar System

MOTION PICTURE FILMS

Solar Family. Encyclopedia Britannica Films Inc.
Moon. Encyclopedia Britannica Films Inc.
Earth in Motion. Encyclopedia Britannica Films Inc.

FILMSTRIPS

The Earth—Revolution and Consequences. Eye Gate
Eclipse of the Sun and Comets. Eye Gate
The Sun's Family. Jam Handy
Our Neighbor the Moon. Jam Handy

Chapter 6. The Changing Earth

MOTION PICTURE FILMS

Birthplace of Icebergs. Teaching Film Custodians Inc.
Mountain Building. Encyclopedia Britannica Films Inc.
The Great Lakes—How They Were Formed. Harry Grubbs
Living Earth Series. Encyclopedia Britannica Films Inc. (color)
  Birth of the Soil
  This Vital Earth
  Arteries of Life
  Seeds of Destruction
Our Soil Resources. Encyclopedia Britannica Films Inc.

FILMSTRIPS

Contour Furrows. USDA
Work of Rivers I and II. SVE
Work of Waves I and II. SVE
Our Earth Is Changing. Jam Handy
How Rocks Are Formed. Jam Handy
The Story of the Earth We Find in Rocks. Jam Handy
The Soil. Jam Handy

Chapter 7. Learning to Buy Wisely

MOTION PICTURE FILMS

Consumer Protection. Coronet Instructional Films
Consumption of Foods. Encyclopedia Britannica Films Inc.
Home Electrical Appliances. Encyclopedia Britannica Films Inc.
How Man Made Day. Coronet Instructional Films

FILMSTRIPS

Proper Care Means Longer Wear. Westinghouse (sound)

Chapter 8. Selection of Suitable Clothing

MOTION PICTURE FILMS

Clothing. Encyclopedia Britannica Films Inc.
Making Shoes. Encyclopedia Britannica Films Inc.
Making Cotton Clothing. Encyclopedia Britannica Films Inc.

FILMSTRIPS

Preparation of Wool for Market. USDA

Chapter 9. Our Earth's Atmosphere

Motion picture films

Atmosphere and Its Circulation. Encyclopedia Britannica Films Inc.
Latitude and Longitude. United World Films Inc.

Chapter 10. Our Earth's Climate

Motion picture films

The Great Winds. United World Films Inc.
The Seasons. United World Films Inc.
Weather. Encyclopedia Britannica Films Inc.

Filmstrips

Climate. Eye Gate
Climate of the West Coast. SVE
Zones and Climate. Eye Gate

Chapter 11. The Business of Being Alive

Motion picture films

How Animals Eat. Young America Films Inc.
How Animals Move. Young America Films Inc.
How Animals Defend Themselves. Young America Films Inc.
Bird Migrations. Heidencamp Nature Pictures
Life Cycle of a Fly. United World Films Inc.
Underground Farmers. Library Films Inc.
Camouflage in Nature. Coronet Instructional Films. (2 reels)
Plant Traps. Encyclopedia Britannica Films Inc.
Flowers at Work. Encyclopedia Britannica Films Inc.
Seed Dispersal. Encyclopedia Britannica Films Inc.
Frog. Encyclopedia Britannica Films Inc.
How Nature Protects Animals. Encyclopedia Britannica Films Inc.
Honeybee. Encyclopedia Britannica Films Inc.

Filmstrips

How Some Animals Get Food. Nature Study Illustrated
How Animals Reproduce Themselves. Nature Study Illustrated
Migration of Birds. SVE

Chapter 12. Enjoying a Garden

Motion picture films

Vegetable Insects. International Film Bureau. (color)
Garden for Abundance. National Garden Bureau. (color)

Gardening. Encyclopedia Britannica Films Inc.
Production of Foods. Encyclopedia Britannica Films Inc.
Truck Farmer. Encyclopedia Britannica Films Inc.

FILMSTRIPS

The Farm Garden. USDA
Home-Grown Plants for Transplanting. USDA
Insect Pests of Garden Vegetables and Their Control. USDA

Where Visual Aids May Be Obtained

Below are the addresses of the sources where the film or filmstrip listed above may be obtained.

CASTLE FILMS DIVISION, United World Films Inc., 1445 Park Ave., New York; or Field Building, 135 S. La Salle St., Chicago 3, Ill.; or Russ Building, San Francisco 4, Calif.

CORONET INSTRUCTIONAL FILMS, 65 E. South Water St., Chicago 1, Ill.; or 207 E. 37th St., New York 16

DAIRY COUNCIL OF ST. LOUIS, 4030 Chouteau Ave., St. Louis 10, Mo.

ENCYCLOPEDIA BRITANNICA FILMS INC., 1150 Wilmette Ave., Wilmette, Ill.

EYE GATE HOUSE INC., 330 W. 42nd St., New York 18

FILMS INC., 330 W. 42nd St., New York 18

GENERAL ELECTRIC CO., Visual Education Division, 1 River Road, Schenectady 5, N. Y.

HEIDENCAMP NATURE PICTURES, 538 Glen Arden Dr., Pittsburgh 8, Pa.

INTERNATIONAL FILM BUREAU, Suite 1500, 6 N. Michigan, Chicago 2, Ill.

THE JAM HANDY ORGANIZATION, 2821 E. Grand Blvd., Detroit 11, Mich.

KNOWLEDGE BUILDERS, 625 Madison Ave., New York 22

LIBRARY FILMS INC., 25 W. 45th St., New York 19

CARL F. MAHNKE PRODUCTIONS, 215 E. 3rd St., Des Moines 9, Iowa

MARCH OF TIME FORUM FILMS, 369 Lexington Ave., New York 17

METROPOLITAN LIFE INSURANCE CO., 1 Madison Ave., New York 10; or 600 Stockton St., San Francisco, Calif.

NATIONAL GARDEN BUREAU, 407 S. Dearborn, Chicago 5, Ill.

NATIONAL MOTION PICTURE CO., W. Main St., Mooresville, Ind.

NATIONAL RETAILERS MUTUAL INSURANCE CO., 7450 Sheridan Rd., Chicago, Ill.

NATIONAL TUBERCULOSIS ASSOCIATION, 1790 Broadway, New York 19

SOCIETY FOR VISUAL EDUCATION INC., 1345 W. Diversey Parkway, Chicago 14, Ill.

TEACHING FILM CUSTODIANS, INC., 25 W. 43rd St., New York 18

U. S. BUREAU OF MINES, Dept. of the Interior, Washington 25, D. C.

U. S. DEPARTMENT OF AGRICULTURE, Extension Service, Washington 25, D. C.

UNITED WORLD FILMS INC., 1445 Park Ave., New York 29

WESTINGHOUSE ELECTRIC CORPORATION, Film Division, 511 Wood St., Pittsburgh, Pa.

YOUNG AMERICA FILMS INC., 18 E. 41st St., New York 17

GLOSSARY

KEY TO SOUNDS OF WORDS

ā as in āble	ē as in ēve	ō as in ōld
ȧ as in chȧotic	ė as in ėvent	ȯ as in ȯbey
â as in câre	ĕ as in ĕnd	ô as in ôrb
ă as in ădd	*ĕ* as in sil*ĕ*nt	ŏ as in ŏdd
ă as in *ă*ccount	ẽ as in makẽr	ŏ as in sŏft
ä as in ärm		*ŏ* as in c*ŏ*nnect
ȧ as in ȧsk	ī as in īce	
ȧ as in sof*ȧ*	ĭ as in ĭll	o͞o as in fo͞od
	ĭ as in char*ĭ*ty	o͝o as in fo͝ot
ou as in out		
oi as in oil	ū as in cūbe	ch as in chair
	ů as in ůnite	g as in go
	û as in ûrn	ng as in sing
	ŭ as in ŭp	th as in then
	ŭ as in circ*ŭ*s	th as in thin
	ü as in menü	tū as in natūre
		dū as in verdūre
		y as in yet
		zh = z as in azure

The accented syllable is marked′. ′ shows a secondary accent.

absorption (*ă*b·sôrp′sh*ŭ*n): the process of taking in something

adapted (*ȧ*·dăp′tĕd): fitted to live in an environment

adequate (ăd′ē·kwĭt): capable of meeting requirements

advertising (ăd′vẽr·tīz′ĭng): drawing attention to things for sale

air mass: a huge quantity of air

algae (ăl′jē): water plants, many of them one-celled

alloy (*ă*·loi′): a mixture of metals

altitude (ăl′t*ĭ*·tūd): a height; an elevation

annealed (*ă*·nēld′): heated and slowly cooled to make stronger

annual (ăn′ū·*ă*l): a plant which lives one season; yearly

annual rings: rings which show the yearly growth of trees

antarctic (ănt·ärk′tĭk): the region near the South Pole

anticyclone (ăn′tĭ·sī′klōn): a large whirling mass of cold air

antiseptic (ăn′tĭ·sĕp′tĭk): a thing free from unwanted germs. The infectious germs were made harmless by the *antiseptic* solution.

antitoxin (ăn′tĭ·tŏk′sĭn): a substance formed in or taken into the blood which makes a person immune to a disease

aphid (ā′fĭd): a plant louse; a small sucking insect

aqueduct (ăk′wē·dŭkt): an artificial channel or a pipe for carrying flowing water

arctic (ärk′tĭk): the region near the North Pole

artesian (är·tē′zhăn) **well**: a well made by drilling into the earth until water under pressure is reached

asteroids (ăs′tẽr·oids): the minor planets whose orbits lie between those of Mars and Venus

astronomer (ăs·trŏn′ō·mẽr): a scientist who studies bodies in space

atmosphere (ăt′mŏs·fẹr): all the air surrounding the earth

atoms (ăt′ŭms): the smallest parts of an element

aurora (ô·rō′rȧ) **borealis** (bō′rē·ā′lĭs): northern lights

bacteria (băk·tẹr′ĭ·ȧ): groups of microscopic plants

ball bearings: the steel balls that roll easily in a groove inside the hub of a wheel

barometer (bȧ·rŏm′ē·tẽr): an instrument for measuring pressure of the atmosphere

basalt (bȧ·sôlt′): a volcanic rock containing iron and other chemicals

beach (bēch): the sandy or gravelly shore of a lake or the sea

bench (bĕnch): a shelf of land

biennial (bī·ĕn′ĭ·ăl): a plant that ends its growth in two years

bleach: a chemical used to whiten clothes

bog: a marsh or a swamp

boll (bōl): the fruit of the cotton plant

borax (bō′răks): a chemical substance used for softening wash water

budget (bŭj′ĕt): a plan showing the best use of available money

bulb: an enlarged underground bud that grows into a plant

bunion (bŭn′yŭn): the swollen joint of the large toe

butte (būt): a flat-topped hill

callus (kăl′ŭs): a hardened place on the skin

capillary (kăp′ĭ·lĕr′ĭ): tiny tubelike space in the soil through which water rises

carbon (kär′bŏn) **tetrachloride** (tĕt′rȧ·klō′rīd): a liquid used in dry cleaning

carrier: a person who bears and transmits disease germs

casein (kā′sē·ĭn): the curd of milk

cesspool: a pit dug to receive waste matter from a drain and from which waste water is absorbed into the ground

chemical: a substance composed of one or more elements

chinook (shĭ·nŏŏk′): a warm winter wind of the western states

chlorine (klō′rēn): a greenish colored gas used to kill certain bacteria in water

chlorophyll (klō′rō·fĭl): the green coloring matter in plants

circuit (sûr′kĭt): the closed path of an electric current

climate: the average weather conditions of a region

cold frame: a glass-covered box used to protect young plants

coli (kō'lī) **bacterium** (băk·tẹr'ĭ·ŭm): harmless bacterium present in the large intestine

comet: a body in space having a long thin tail

competition (kŏm'pē·tĭsh'ŭn): a striving to win

compost (kŏm'pōst): a mixture of decomposed vegetable matter used for fertilizing

compress (kŏm·prĕs'): to force into a smaller space; to press or squeeze together

conduct (kŏn·dŭkt'): to carry or transmit

conglomerate (kŏn·glŏm'ẽr·ĭt): a rock containing cemented pebbles

consumer: a person who uses goods

contagious (kŏn·tā'jŭs): catching. Scarlet fever is a *contagious* disease.

contour (kŏn'tōōr) **line**: a line through points of equal elevation

convection (kŏn·vĕk'shŭn): transfer of heat by currents of gases or liquids

copyright: the sole legal right to use

crater (krā'tẽr): the opening of a volcano

crib: a penlike building in a lake to keep water clean

cultivation: the loosening of soil for crops

culture (kŭl'tūr): a gelatin prepared for growing bacteria

cumulus (kū'mū·lŭs): a thunder cloud; a heaped-up looking cloud with a flat bottom

cutting: a piece cut from a plant used to start a new plant

cyclone: a large rising, whirling mass of warm air

cylinder (sĭl'ĭn·dẽr): a hollow, round metal tube through which a piston moves

DDT: a chemical insect killer

decay: spoilage by action of bacteria

deciduous (dē·sĭd'ū·ŭs): falling off of leaves in winter

decompose (dē'kŏm·pōz'): to break down into its parts

density: the amount of anything in a certain space; thickness

design: the pattern or plan of something

detergent (dē·tûr'jĕnt): a cleaner used instead of soap. We washed the dishes with a *detergent.*

diameter: the distance through the center of a circle

disease: a sickness; an illness

drift: wind-driven surface waters

dynamo (dī'nȧ·mō): a machine for making electricity

earthquake: a violent movement of the earth's crust

eclipse (ē·klĭps'): the darkening of the sun or the moon when something comes between the earth and sun or moon, cutting off the light

economy: saving

egg cell: female germ cell

electromagnet (ē·lĕk'trō·mag'nĕt): an iron core becoming magnetic when it is wrapped with wire through which electricity flows

elevation: height above sea level

embryo (ĕm'brĭ·ō): the earliest stage of development of a plant or an animal

emotion (ē·mō'shŭn): a strong feeling

emulsion (ē·mŭl'shŭn): a mixture of oil with other substances

endorsement (ĕn·dôrs′mĕnt): approval; consent

energy: the capacity for doing work

environment (ĕn·vī′rŭn·mĕnt): the surroundings of living things

erosion (ē·rō′zhŭn): a wearing action on the land

evaporation (ē·văp′ō·rā′shŭn): the change of a liquid to its gas form

fad: an extreme style which does not last very long

fashion: an accepted style of clothing or goods

fault: the displacement of masses of rock

fertilizer (fûr′tĭ·līz′ẽr): a nourishment for plants

fiber: a tough threadlike substance

field magnet: the outer magnet in an electric motor

filter (fĭl′tẽr): a strainer through which liquids pass

fixed point: a point marked on a thermometer at which water freezes or boils

fluorescent (flo͞o′ō·rĕs′ĕnt): glowing, as a lamp painted on the inside glows when electricity is turned on

fluorine (floo′ō·rēn): a chemical element sometimes used to prevent tooth decay

foot-candle: the brightness of one candle at a distance of one foot

foot-pound: the energy needed to lift a pound for a distance of one foot

force: a push or a pull

friction: rubbing; resistance to motion

fulcrum (fŭl′krŭm): a support on which a lever turns

function (fŭngk′shŭn): the purpose or process of a thing

fungus (fŭng′gŭs): a plant with no green coloring matter

garbage (gär′bĭj): the waste food from kitchens

gear: a notched wheel used to carry power to another part of a machine

germicide (jûr′mĭ·sīd): a chemical for killing germs

germination (jûr′mĭ·nā′shŭn): the development or growth of a seed

glare: a dazzling light

glider (glīd′ẽr): an airplane with no motor

granite (grăn′ĭt): a rock containing large coarse crystals

graph (gråf): a diagram showing amounts

gravitation (grăv′ĭ·tā′shŭn): gravity; the pull of all objects on all other objects

great circle: the shortest route between parts of the world; a circle on the surface of a sphere having its plane pass through the center of the sphere

ground water: water held in the ground in soil and rocks

growth: an increase in size or a change in form

hard water: scum-forming water containing dissolved minerals

heat: the energy of moving molecules which can be passed from one molecule to another

heat equator: a line around the earth

connecting the points of highest temperature

helicopter (hĕl′ĭ·kŏp′tẽr): aircraft supported and flown by revolving blades

hibernate (hī′bẽr·nāt): to pass the winter in an inactive state

horse latitude (lăt′ĭ·tūd): the belt of calms between the westerlies and the trade winds

hot bed: a bed of earth heated by fermenting manure and used to start plants

humid: damp; moist

humidity (hū·mĭd′ĭ·tĭ): the moisture in the air

humus (hū′mŭs): partly decayed vegetable matter in soil

hurricane (hûr′ĭ·kān): a violent rising, whirling wind

hygrometer (hī·grŏm′ē·tẽr): an instrument for measuring humidity

hypothesis (hī·pŏth′ē·sĭs): an idea to be tested

igneous (ĭg′nē·ŭs) **rock:** a kind of rock cooled directly from the melted state

immune (ĭ·mūn′): having resistance to a disease

impervious (ĭm·pûr′vĭ·ŭs): resisting the passage of water, as a rock

impulse (ĭm′pŭls): a sudden feeling

inclined (ĭn·klīnd′) **plane** (plān): a sloping surface

incubation (ĭn′kū·bā′shŭn): the period of time necessary for the hatching of eggs or for the development of a disease

inertia (ĭn·ûr′shȧ): the resistance of objects to being moved or stopped

infection (ĭn·fĕk′shŭn): a condition in which disease germs are developing

inferior (ĭn·fēr′ĭ·ẽr): lower in position

infrared (ĭn′frȧ·rĕd′) **waves:** heat waves

inherit (ĭn·hĕr′ĭt): to obtain from a parent

inoculate (ĭn·ŏk′ū·lāt): to put germs into the body causing a mild form of a disease so that the person will not take that disease

insulate (ĭn′sū·lāt): to cover with a nonconducting material

irrigation (ĭr′ĭ·gā′shŭn): a means of supplying the land with water

isolation (ī′sō·lā′shŭn): the separation of sick people from well people

isotherm (ī′sō·thûrm): a line running through points of equal temperature

jet plane: a plane propelled by escaping gases

kinetic (kĭ·nĕt′ĭk) **energy:** the energy of matter in motion

larva (lär′vȧ): the wormlike young of insects

latitude (lăt′ĭ·tūd): the distance from the equator

lava (lä′vȧ): the melted rock issuing from volcanoes

lever (lē′vẽr): a bar used to pry or lift objects

limestone (līm′stōn′): a rock formed from shells and skeletons

locomotion (lō′kō·mō′shŭn): the movement of organisms from place to place

lye: a strong chemical substance

naphtha (năf′thȧ): a kind of gasoline

neap (nēp) **tide:** the lowest tide

nichrome (nī′krōm): an alloy of iron, nickel, and chromium

nymph (nĭmf): the middle stage in the growth of some insects

magma (măg′mȧ): a melted rock flowing underground

magnesium (măg·nē′shĭ·ŭm): a metal lighter than aluminum

magnitude (măg′nĭ·tūd): the brightness of stars

mammal (măm′ăl): an animal which feeds its young on milk

masculine (măs′kū·lĭn): manly

maximum (măk′sĭ·mŭm): the highest

mechanical (mē·kăn′ĭ·kăl) **energy:** the energy of moving objects

membrane (mĕm′brān): a thin skin or tissue

mental attitude: thought influenced by feelings

metamorphic (mĕt′ȧ·môr′fĭk): changed in form by heat or pressure

meteor (mē′tē·ẽr): a glowing particle of rock attracted to the earth from outer space

meteroite (mē′tē·ẽr·īt): the unburned remains of a meteor

migrate (mī′grāt): to move from one region to another

mineral (mĭn′ẽr·ăl): a substance that is neither plant nor animal contained in the earth or soil

minimum: the lowest

molecules (mol′ē·kūlz): the smallest particles of ordinary matter

monsoon (mŏn·sōōn′): a wind that changes direction with the seasons

orbit (ôr′bĭt): the path of a body through space

organism (ôr′găn·ĭz′m): a living thing

ovary (ō′vȧ·rĭ): the part of a plant or animal producing egg cells

oxidation (ŏk′sĭ·dā′shŭn): the combination of another material with oxygen

oxide (ŏk′sīd): a chemical compound formed by the combination of oxygen and another material

parasite (păr′ȧ·sīt): an organism that lives on another

pasteurize (păs′tẽr·īz): to kill germs by heat

perennial (pẽr·ĕn′ĭ·ăl): a plant which lives for several years

perspiration (pûr′spĭ·rā′shŭn): sweat

phase (fāz): a change in the apparent shape of the moon or a planet

phosphorus (fŏs′fō·rŭs): an element; a part of fertile soil

photoelectric (fō′tō·ē·lĕk′trĭk) **cell:** a device used to measure the brightness of light

pistil (pĭs′tĭl): the part of a flower containing the ovary and egg cells

piston (pĭs′tŭn): the part which

moves in the cylinder of a machine

plane: a flat surface or space

planet: a body moving around the sun

plateau (plă·tō′): a plain at a high elevation

pollen (pŏl′ĕn): the dustlike part of a flower producing sperm cells

polluted (pŏ·lūt′ĕd): impure; unsafe

porous (pō′rŭs): full of spaces

potassium (pō·tăs′ĭ·ŭm): an element found in fertile soil and needed by plants

potential (pō·tĕn′shăl): stored up

power: doing work at a certain rate

precipitate (prē·sĭp′ĭ·tāt): to go out of solution or to condense and fall

prevailing (prē·vāl′ĭng) **westerlies** (wĕs′tĕr·lĭz): two belts of west winds in the United States

propeller (prō·pĕl′ĕr): the bladelike part of an airplane turned by the motor

protozoa (prō′tō·zō′ȧ): one-celled animals

prune: to trim off branches

psychologist (sī′kŏl′ō·jĭst): a scientist who studies the behavior of people

pulley: a wheel over which a rope passes

pupa (pū′pȧ): the resting stage in the growth of insects

quality: grade or kind

radiant (rā′dĭ·ănt): giving off rays of heat or light

rayon: a silklike cloth made from plant fibers and chemicals

redwoods (rĕd′wo͝odz′): huge trees with brownish-red wood

relative (rĕl′ȧ·tĭv) **humidity:** the amount of water vapor in the air

repel (rē·pĕl′): to push away

reproduction (rē′prō·dŭk′shŭn): creating new individuals

research (rē·sûrch′): study and experiment to solve problems

reservoir (rĕz′ĕr·vwôr): a storage tank

resistance (rē·zĭs′tăns): opposition to an electric current or other force

revolution (rĕv′ō·lū′shŭn): the movement of the earth or other body in its orbit

rodents (rō′dĕnts): gnawing animals

rotation (rō·tā′shŭn): the turning motion of a body on its axis

rotor (rō′tĕr): the central part of a motor moved by magnetic force

scale insect: an insect pest on plants

screw: an inclined plane wrapped around a rod

sedimentary (sĕd′ĭ·mĕn′tȧ·rĭ): formed from material deposited by water

septic (sĕp′tĭk) **tank:** a tank to receive and decompose sewage

settling basin: a pool in which mud from city water settles

sewage (sū′ĭj): the waste from the bathroom, kitchen, and laundry

silt: fine soil materials washed down by running water; sand

siphon (sī′fŏn): a pipe for carrying water over an elevation to a low place

slogan (slō′găn): a word or phrase used in selling
sludge (slŭj): the remains of solid wastes after bacteria have worked on them
social: living in colonies; pertaining to human beings
solar (sō′lẽr): of the sun
species: (spē′shĭz): a certain kind
spectrum (spĕk′trŭm): the band of colors from sunlight
sperm (spûrm) **cell:** the male cell necessary for reproduction
spiracle (spī′rȧ·k'l): the opening of the breathing tube of an insect
spontaneous (spŏn·tā′nē·ŭs) **combustion** (kŏm·bŭs′chŭn): self-starting burning
spring tide: the highest tide after the full moon
stalactite (stȧ·lăk′tīt): the icicle-like stone formation in caves
stalagmite (stȧ·lăg′mīt): the moundlike pillar beneath a stalactite
stamen (stā′mĕn): the part of the flower producing pollen
stomate (stō′māt): the opening in a leaf for taking in air
stratosphere (străt′ō·sfēr): the layer of air just above the layer in which we live
style: fashion
sunspot: a swirling mass of cooler gas on the sun
surface water: water in streams or lakes
synthetic (sĭn·thĕt′ĭk): made by use of chemicals

temperate (tĕm′pẽr·ĭt): moderate
thermograph (thûr′mō·gráf): an instrument that records the temperature
thermometer: an instrument for measuring temperature
thrip (thrĭp): a tiny flylike insect pest found in the soil
tornado (tôr·nā′dō): a small violent, rising, whirling windstorm
trachea (trā′kē·ȧ): the breathing tubes of insects; the windpipe
trade winds: winds blowing toward the equator
transplant (trăns·plȧnt′): to dig up and replant
tropics (trŏp′ĭk): the regions nearest the equator
tunnel: an underground tube

ultraviolet (ŭl′trȧ·vī′ō·lĕt) **rays:** invisible rays from the sun

vaccinate (văk′sĭ·nāt): to place vaccine in the skin of a person to prevent small pox
vacuum (văk′ū·ŭm): a space from which air has been taken
vane: the blade of a windmill
vapor (vā′pẽr): the gaseous form of a substance
variety (vȧ·rī′ĕ·tĭ): a division of a species of plants
velocity (vĕ·lŏs′ĭ·tĭ): swiftness; speed
veneer (vĕ·nẹr′): a thin layer of wood glued to another
vibrate (vī′brāt): to move back and forth
virus (vī′rŭs): a substance smaller than bacteria that causes disease

water table: the upper level of ground water

wedge: a tool both sides of which is an inclined plane

weed: a plant growing where it is not wanted

weight: the pull of gravity on an object

wheel and axle: a type of lever

wind tunnel: a tunnel for studying effect of air currents on aircraft

work: causing something to move

X-ray: a ray used to take pictures of the interior of the body

INDEX

DATE DUE
